ASSESSMENT OF BREADTH AND UTILITY OF INDIA'S RESEARCH LITERATURE (2005-2006)

Mr. Robert Miller
DDL OMNI Engineering LLC
8260 Greensboro Drive, Suite 600
McLean, Virginia 22102

Dr. Ronald N. Kostoff
Office of Naval Research (Ret'd)
875 North Randolph Street
Arlington, Virginia 22217

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Executive Summary

This report provides an assessment of India's science and technology (S&T) literature based on use of advanced textual data mining (TDM) tools and procedures. The assessment identifies the S&T core competencies of India, and provides a comparison of representative competencies with other select countries. The TDM process uses computational linguistics to identify main research thrusts, the volume of research output in main research thrusts, and the relative quality of select major thrusts. Aggregate publication and citation bibliometrics were identified, and hierarchical taxonomies were generated for Indian research. Additionally, bibliometrics and thematic trends were identified for the past two decades. The work was performed in support of an overall Office of Naval Research and Naval Surface Warfare Center, Dahlgren Division effort to apply new systematic TDM approaches for assessing both national and international S&T investment trends under Contract No.: N00178-04-D-4032, (DO) 0002. The following paragraphs describe the overall structure of the report.

Section 1 (INTRODUCTION) states the primary objectives and provides background information on the overall approach used to assess India's S&T literature. The current approach combines three concepts including: 1) Core competency determination, 2) Country technology assessments, and 3) TDM assessments. Section 1 also provides updated information on India's S&T organization, and total budget allocations to various S&T Departments and Ministries for the period (2005-2006).

Section 2 (OVERALL APPROACH) provides discussion on the approach used to assess India's S&T literature. In general, two major types of information are required for India's S&T core competency assessment. The first type is technical infrastructure, which encompasses the prolific authors and affiliations, prominent cited journals, and the most cited research articles. The second type of information is associated with technology thrusts, and the relationship among the thrusts. This present study focused on obtaining both types of information, and as such, two types of analysis results are presented, bibliometrics and taxonomies. Bibliometrics provide an indication of the technical infrastructure, while taxonomies provide an indication of major technology thrusts and their relationships.

Section 3 (BIBLIOMETRICS APPROACH and RESULTS) provides detailed discussion on the bibliometric approach and analysis results. Two types of bibliometrics are summarized: 1) Publication and 2) Citation. Publication bibliometrics are counts of papers published by different entities (e.g., authors, research institutions, industry, etc.). Citation metrics are counts of citations to papers published by different entities.

Section 3.1 (Overall India Bibliometrics) provides information for identified temporal publication trends, journals containing most articles, journals cited most frequently by India authors, most prolific institutions, and most collaborative countries for the aggregate India database.

Section 3.2 (Prominent Journals) provides information on the prominent journals in which India authors publish, including journal impact factors (measures of a journal's ability to attract citations). The analysis specifically addresses journals containing most India-authored research articles and most cited journals.

Section 3.3 (Prolific Affiliations) provides detailed bibliometric analysis results that identify not only the most prolific affiliations associated with India authors, but also which affiliations collaborate significantly on research publications. The analysis uses several independent methods to provide progressive insight into the nature or attributes of specific research collaboration groups (links), and allow detailed correlation analysis between research article attributes (data fields) including authors, affiliations, subject categories, keywords and journals. The analysis specifically identifies these most prolific affiliations (institutions) and their collaboration linkages (based on total number of articles) through use of several methods including:

1) Affiliation Co-occurrence Matrices
2) Affiliation Auto-correlation Maps
3) Affiliation Factor Matrices, and

Additional methods are employed to identify specific affiliation collaboration linkages (based on common terminology and Journals) including:

4) Affiliation - Phrase Co-occurrence Matrices
5) Affiliation x Phrase Cross-correlation Maps
6) Affiliation - Journal Co-occurrence Matrices

Section 3.4 (Collaborative Countries) identifies the main collaborating countries with India on research articles, and provides updated journal citation report (JCR) data for the period 2005-2006. Gross bibliometric analyses are presented that provide an overall perspective on India collaborative research by addressing the effects of collaboration (co-authorship), through use of several country address queries, on output production (total articles published); and regarded research utility (article citations and associated journal impact factors). This analysis also addresses the collaboration impact (effects) of prolific authors, other countries, and highly ranked journals on output production, and article citation trends. Specifically, the effects through systematic exclusion of Top 10 authors, affiliations, collaborating countries, and ranked journals, on total publication output and highly cited research articles is determined.

Section 4 (TAXONOMIES - DOCUMENT CLUSTERING) presents the pervasive technical themes of India's research, the relationships among those themes, and the levels of emphasis (number of research articles published) associated with each of the themes. The general approach that was used required grouping the retrieved raw records into categories of similar research articles, identifying the central themes through phrase analysis of the articles in each category, and tabulating the number of articles associated with each category. Many approaches for grouping these records have been developed and used for general data mining analyses. The analyses presented uses a document clustering approach, based on favorable results from previous text mining studies. Document clustering is the grouping of similar research articles into thematic categories that is depicted in the present study as a hierarchical tree that represents the overall taxonomy of India's research.

Section 4.1 (Document Clustering Results) provides detailed discussions on the clustering approach and analysis results for each database. Select clustering was performed for the SCI/SSCI, EC and INSPEC (2005-2006) databases based on the total relative number of records retrieved from each database. The number of cluster nodes selected for the SCI/SSCI record retrievals equaled 256 (2^8), and 128 (2^7) cluster nodes were selected for both the EC and INSPEC retrievals. The cluster nodes comprising Levels (0-4) of the SCI/SSCI, EC and INSPEC (2005-2006) database hierarchical taxonomies are described in detail. For each of the nodes in the first four levels (0-3), there are two types of data generated by the computer output. The first type of data is *Syntax* comprising descriptive terms (Themes their numerical weightings), and phrase groupings). The second type of data is computer-generated *Metrics* comprising prolific authors, author countries and affiliations, keywords (author supplied) and journals.

A complete and comprehensive analysis of cluster nodes for the SCI/SSCI, EC and INSPEC (2005-2006) database taxonomies are provided in a separate publication to this Summary Report (Ref: 17 Appendices C, D and E, respectively). Due to the sheer volume of combined information for all databases, only Level 1 and 4 nodes are addressed.

Section 4.2 (Extended India Research Collaboration Analysis – Thin Film Research) provides detailed discussions on an extended research collaboration analysis. The document clustering results for the SCI/SSCI, EC, and INSPEC databases (Level 4 Clusters) for the period (2005-2006) indicate that solid thin films is one viable single technology focus area that warrants extended analyses. Therefore, a generalized single technology query was developed to retrieve the maximum number of records from each database in order to conduct extended India research collaboration analyses focused on solid thin films. The analyses comprise gross bibliometrics for all collaborating countries (based on co-authorship), prominent journals, author affiliations, and thin film subject categories. The analyses also comprise detailed article publication and citation trend analyses for the period (2005-2006) and for the extended period (1980-2005) by intervals.

In addition, the clustering results for the SCI/SSCI, EC, and INSPEC databases (Level 4 Clusters) indicate that agronomy, and plant biochemistry and biotechnology with focus on genetic resources/crop evolution were also identified as a single technology focus area that appeared predominantly across all three databases. As such, Section 4.3 (Extended India Research Collaboration Analysis - Crops/Soil Research) provides an extended research collaboration analysis for this focus area, parallel to the analysis for solid thin films.

Lastly, Section 4.4 (Extended India Research Collaboration Analysis - Subject Categories) provides analysis results intended to establish a keener perspective and more detailed overview of the collaborative nature of India research with the USA and Peoples Republic of China. Specifically, the analysis addresses the impact (effects) of collaboration on the overall regarded utility of research based on article citations and associated journal impact factors, and determines if these effects are evident across a much broader, generalized taxonomy of India research (subject categories), as opposed to the single-technology level.

Section 5 (RESEARCH EXPENDITURE / OUTPUT COMPARISON) provides the final analysis of the India S&T literature assessment and examines the relation between the budget allocations for each India S&T Department/Ministry (2005-2006) and the total combined categorized output from all databases. Specifically, the total categorized output comprises all combined research articles from each set of SCI/SSCI, EC and INSPEC Level 4 clusters (research focus areas) identified from taxonomy analyses. Aggregate category headings for the Level 4 clusters were used to produce research output categories for classification under the eight S&T Department/Ministry research expenditure areas (excluding Defense Department and Non-conventional energy). Analysis results include a complete listing of relative budget allocations, total number of research articles, and the ratio of budget allocation percentage assigned to the eight expenditure areas to the percentage of research articles assigned to these same areas.

Section 6 (MAJOR FINDING AND CONCLUSIONS) provides a summary of all major findings and related conclusions based on the bibliometrics and document clustering analysis results discussed in the preceding sections. A summary of these results is provided below. It should be noted that a complete and comprehensive documentation of all analysis results is provided in a separate publication (Ref: 17) that accompanies this summary report.

Overall India Bibliometrics

All research articles in the SCI/ SSCI, EC and INSPEC databases having at least one author with an India address were retrieved for the time periods (1980-2005) and (2005-2006)

- The total output production (total of number of published articles at least one author with an India address) over the entire period (2005-2006) was distributed as follows.

SCI/SSCI Total Articles	= 52,047
EC Total Articles	= 4,430
INSPEC Total Articles	= 5,506
Total Articles	= 61,983

- The total output production (total of number of published articles at least one author with an India address) over the entire combined period (1980-2006) was distributed as follows.

SCI/SSCI Total Articles	= 419,116
EC Total Articles	= 139,159
INSPEC Total Articles	= 155,976
Total Articles	= 714,251

- A comparative analysis was performed for the Peoples Republic of China. All research articles in the SCI/ SSCI, EC and INSPEC databases having at least one author with an China address were retrieved for every year from 1980-2006.

    * The differences between China and India are dramatic! In the SCI/SSCI database from 1980-2006, China's research article output increased by two orders of

magnitude (731 articles - 82,205 articles), while India's output increased by 2.5 (10,606 articles - 26,814 articles), a factor of forty difference! Similarly, in both the EC and INSPEC databases (combined), China's research article output increase is even more dramatic (1376 articles - 189,997 articles), while India's output increased by 3.5 (7,038 articles - 24,245 articles), again a factor of forty difference!

- For the SCI/SSCI database, the publication trends for countries that collaborate with India on basic research indicate the percentage of records published by the Top 10 collaborators ranged from approximately 0.76 % (Australia) – 6.9 % (USA) for the period (2000-2005). The percentage of records published by the Top 10 collaborators ranged from approximately 0.85 % (Australia) – 6.9 % (USA) percent for (2005-2006). USA has remained as the most dominant collaborator for the entire period (1980-2006). In addition, Asian countries including Japan, Peoples Republic of China, and South Korea have recently significantly increased their respective bilateral and multilateral collaboration efforts with India.

- Further analysis indicates India and China are increasing their growth of articles in highly cited journals greater than their overall increase in growth of research articles. India's relative increase is modest, whereas China's increase is strong. For both countries, much of the increase in overall research article growth comes from increasing production of articles in low Impact Factor domestic and international journals. In addition, for both countries, there is increased production in high Impact Factor journals as well. The increase in high Impact Factor journals outpaces the increase in overall research article production, but the high Impact Factor journal production is a relatively small fraction of the overall research article production.

Prominent Journals

The top journals in which India authors publish, including journal impact factors (measures of a journal's ability to attract citations) were identified. The analysis specifically addresses journals containing most India-authored research articles and most cited Journals.

- A benchmark for journals containing the most research papers published by authors in India, USA, and China was established indicating that USA journal impact factors are an order of magnitude greater than those for China or India. It was also shown that collaboration has the effect of dramatically increasing the presence of papers with India authors in the higher impact factor journals.

- Aggregate journal citation metrics, for all research articles retrieved from the SCI/SSCI database during the period (2005-2006) indicates that the impact factors for the most cited journals are an order of magnitude higher than the impact factors of the journals that contain the most India papers.

- Thus, India authors are citing the high impact factor journals extensively, but not publishing in them extensively.

- The most cited Indian journals are all distributed towards the lowest total of cites, and only account for approximately 1.3% (18,301) of the total 2005 cites (1,436,677).

Prolific Affiliations

Detailed bibliometric analysis results identified not only the most prolific affiliations associated with India authors, but also which affiliations collaborate significantly on research publications. These analysis methods provided progressive insight into the nature or attributes of specific research collaboration groups (links), and allowed detailed correlation analysis between research article attributes (data fields) including authors, affiliations, subject categories, keywords and journals. The analysis results indicate the following:

- Affiliation - Phrase cross-correlation maps and Affiliation auto-correlation maps (2005-2006) show central cores of Indian research based on common terminology, with the more basic research centered about the Indian Institute of Science (IISc) and the more applied research centered about the Indian Institute of Technology (IIT).

- Numerous technically based groupings can be discerned from the SCI/SSCI cross-correlation maps including: 1) a large chemistry-oriented group comprising several IIT chemistry departments, the Central Drug Research Institute and several leading universities; and 2) a strong linkage between the Tata Institute of Fundamental Research and the Institute of Theoretical and Experimental Physics, Moscow.

- The EC and INSPEC cross-correlation structure includes a large applied chemistry-oriented group comprising several IIT and IISc chemistry departments, Central Electrochemical Research Institute and several leading universities.

Collaborative Countries

During the preceding study, the SCI/SSCI database was accessed in March 2006 to identify the main collaborating countries with India on research articles, for the period (2004-2005). For comparative purposes, this study provides updated journal citation report (JCR) data, accessed in March 2007, for the period (2005-2006). The results for both periods are summarized as follows:

- All collaborative countries account for approximately 22% of the total records published for both given periods, with USA as the predominant collaborator (total records = 6,790 or approximately 31% of the total records for all collaborative countries).

- Although the USA is the predominant collaborator, in terms of both total records and average cites per year, the average cites per record (3.81) is significantly less than for other collaborative countries, such as Russia (10.88), Peoples Republic of China (7.4), France (5.99) and Australia (5.96).

- Bilateral and multilateral collaborative research (based on co-authorship) with USA and China is being published in relatively high IF journals. The average Top 25 journal IF = 3.159 for India and USA; and 1.716 for India and China co-authorship, respectively.

Taxonomies - Document Clustering

The pervasive technical themes of India's research, the relationships among those themes, and the levels of emphasis (number of research articles published) associated with each of the themes were identified using a document clustering approach. Document clustering is the grouping of similar research articles into thematic categories that can be depicted as a hierarchical tree representing the overall taxonomy of India's research.

- Detailed clustering analysis was performed individually for the SCI/SSCI, EC and INSPEC (2005-2006) databases (Ref: 17). Analysis results provided matrices that synopsized of the first five levels (0-4) of the SCI/SSCI, EC and INSPEC hierarchical taxonomies, where each cell in a matrix lists representative technical categories.

- The respective taxonomies generated by the CLUTO clustering algorithm essentially paralleled the subject coverage areas for each database. The taxonomies generated for the EC and INSPEC databases reflect more focus on Applied Physical Sciences, Materials Engineering, Electrical Engineering, and Electronics. Table 8 provides a comparative listing of Level 4 clusters for each database, including details on research focus areas.

Extended India Research Collaboration Analysis – Solid Thin Films Research

The document clustering results indicate solid thin films is one viable technology focus area that warrants extended research collaboration analyses based on the total related publications retrieved from all databases. The analyses focused on India thin film research (indigenous and collaborative) with the United States (USA) and Peoples Republic of China, based on co-authorship.

- The extent (scope) of India thin film research in terms of overall indigenous output production in a given time period (1980-2006) is determined by total publication trends. These trends indicate a steady publication growth rate during the entire period that has rapidly exceeded 10.4 % for the recent period (2005-2006). Indigenous research output contains only Indian authors.

- The extent of India thin film research collaboration with both the USA and China in terms of overall output production in the period (1990-2006), is determined by the total publication and article citation trends that show steady growth rates during the entire period.

- Collaborative thin film research with USA and China authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to indigenous research being published by only India authors.

- The specific Journals or Conference Proceedings comprising indigenous India thin film research articles is a broad collection of journals with varying citations and impact factors.

- Primary collaborating countries other than the USA or China include Germany, Japan, South Korea, France, Taiwan, England, Switzerland and Italy.

- Prominent Indian (indigenous) thin film research focus areas and publication topics identified from all databases include:

  1. Development of fast ion beam sources for engineering the micro- and nanostructural properties of thin films. Focus is on metallic and rare earth ion beams that have important roles in nano-technology and enhancement of optical properties of semiconductor nano-particles inside various matrices.
  2. Polycrystalline and nanoparticle thin film formation using vacuum evaporation and inert gas evaporation techniques, respectively.
  3. Multilayer heterostructural thin film formation using e-beam evaporation techniques to synthesize metallic contacts for nanoscale devices (nanomixing). Swift ion sources are then used to tailor micro- and nanostructural properties.
  4. Thin film formation using sol-gel techniques and characterization of structural and dielectric properties using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), AC conductivity techniques.

- Prominent thin film research focus areas and publication topics identified for articles containing both India and Peoples Republic of China author addresses include:

  1. Thermally grown ultra-thin silicon dioxide (SiO2) films and characterization of stress-induced leakage currents (SILC) using stressing and sensing measurements. Experimental results provide physical insight into the conduction mechanism of SILC through ultra-thin SiO2 films stressed in the direct tunneling (DT) regime.
  2. Development of carbon nanotubes (CNTs) and carbon nanofibers (CNFs) using thermal CVD processes. These materials were used as the electrode platinum support for fuel cell evaluations.
  3. Development of metal-oxide-semiconductor (MOS) structures with hafnium oxide as the gate dielectric film, and the investigation of current-voltage (I-V) characteristics.

- Prominent thin film research focus areas and publication topics identified for articles containing both India and USA author addresses include:

  1. Development of Zn1-xMnxO thin films grown on Al2O3 and MgO substrates, and investigation of ferromagnetic behavior, and spin polarization of charge carriers. These single-phase films are being characterized for magnetic semiconductor applications.
  2. Development of Cr-doped In2O3 thin films with tunable ferromagnetic behavior over a wide range of doping, or by electrical gating, is being investigated towards realizing

spin electronics in magnetic semiconductors and developing spin-based multifunctional devices.

3. Development of amorphous superconducting films driven normal by a perpendicular magnetic field, and investigation of low-temperature behavior.

A final perspective on the countries that dominated globally in thin research output (total publications) over the period (1980-2006) indicates:

- The USA as the leader in total publications in all databases (ranked 1st @ 389,684 articles) over the entire period.
- The total publications for the Peoples Republic of China (ranked 2nd @ 115,893 articles), is approximately 30% of the total for the USA.
- The total publications for India (ranked 9th @ 33,167 articles), is approximately 9% of the total for the USA. Thus, from a global perspective, India is prominent, in terms of both indigenous and collaborative thin film research output, and ranked in the Top 10 nations. Analysis provided above indicated that the predominant countries collaborating with India on thin film research over this period include in order; USA, Germany, France, Japan South Korea, Italy, Taiwan, Peoples R China (2nd in publications), and the United Kingdom.

Extended India Research Collaboration Analysis – Crops/Soil Research

The document clustering results indicate crops/soil is one viable research focus area that warrants extended research collaboration analyses based on the total related publications retrieved from all databases. The analyses focused on India thin film research (indigenous and collaborative) with the United States (USA) and Peoples Republic of China, based on co-authorship.

- The extent (scope) of Indian crops/soil research in terms of overall output production in a given period (1980-2006) is determined by the total publication trends. These trends further indicate a steady publication growth rate during the entire period (1980-2006).

- The extent of India crops research collaboration with both the USA and China in terms of overall output production in a given period (1990-2006), is determined by the total publication trends. The total publication and article citation trends show steady growth rates during the entire period.

- Collaborative crops/soil research with USA and China authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to indigenous research being published by only India authors.

- The specific Journals or Conference Proceedings comprising indigenous India crops/soil research publications is a broad collection of literature journals with varying citations and impact factors, as indicated by the bibliometric trends.

- Primary collaborating countries other than the USA or China include United Kingdom, Philippines, Germany, Australia, Japan, Canada, and Netherlands.

- Prominent Indian (indigenous) crops/soil research focus areas and publication topics identified from all databases include:

  1. The map-based sequence of the rice genome is being investigated under the International Rice Genome Sequencing Project. Rice, one of the world's most important food plants, has important syntenic relationships with the other cereal species and is a model plant for the grasses. The map-based sequence has proven useful for the identification of genes underlying agronomic traits and could accelerate improvements in rice production.
  2. Case studies to assess the long-term effect of sewage irrigation on heavy metal content in soils, plants and groundwater. The gradual decline in availability of fresh water to be used for irrigation in India demands the use of sewage and other industrial effluents for irrigating agricultural lands.
  3. Development of separation and purification technology for removal and recovery of malachite green from wastewater using an agricultural waste material, de-oiled soya. De-oiled soya is a waste product obtained during the processing of soyabean in soya oil extraction mills. Attempts are being made to exploit this crop as waste material and low cost adsorbent for the removal of toxic textile dye 'malachite green'.
  4. Bottom ash, a power plant waste, and de-oiled soya, an agricultural waste material, is also being used for removal and recovery of *Amaranth* and Quinoline Yellow water-soluble *hazardous* dyes.

- Prominent crops/soil research focus areas and publication topics were identified for articles containing both India and China addresses including:

1. Collaboration on the International Rice Genome Sequencing Project to investigate the map-based sequence of the rice genome (see above).
2. Collaboration on the Tomato Sequencing Project, the first cornerstone of the International Solanaceae Project (SOL) (see above).
3. Investigation of water saving technologies for sustaining and increasing the productivity of rice-wheat systems. Current technologies for reducing irrigation water requirements include laser leveling, direct drilling, raised beds, non-ponded rice culture and irrigation scheduling. Studies indicate that rehabilitation and improvement of canal and power systems in Asia are required to facilitate adoption of many water saving technologies.

- Lastly, prominent crops/soil research focus areas and publication topics were identified for articles containing both India and USA addresses including:

1. Collaboration on the International Rice Genome Sequencing Project to investigate the map-based sequence of the rice genome (see above).
2. Collaboration on the Tomato Sequencing Project, the first cornerstone of the International Solanaceae Project (SOL) (see above).

3. Investigation and modeling of Greenhouse gas emissions (simulate methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2)) from Indian rice fields using various management practices. The study suggested models could be applied for estimating the gas emissions and the influences of agronomic management, soil and climatic parameters.

A final perspective on countries that dominated globally in crops/soil research output over the period (1980-2006) indicates:

- USA is the leader in total publications in all databases (ranked 1st @ 88,969 articles) over the entire period.
- The total publications for the Peoples Republic of China (ranked 2nd @ 19,397 articles), is approximately 22% of the total for the USA.
- The total publications for India (ranked 6th @ 11,494 articles), is approximately 13% of the total for the USA. Thus, from a global perspective, India is prominent, in terms of both indigenous and collaborative thin film research output, and ranked highly in the Top 10 nations.
- Predominant countries collaborating with India on crops/soil (agronomy) research over this period include in order; USA, Germany, United Kingdom, South Korea, Australia, Peoples R China (2nd in publications), Philippines, Japan, France, and Netherlands.
- India is conducting crops/soil research focused on a wide breadth of applications. The overall taxonomy of crops/soil research (indigenous and collaborative) in terms of predominant generalized subject categories comprises agronomy, plant sciences, microbiology and biotechnology, environmental biology, genetic resources and crop evolution, and food processing technology.

Extended India Research Collaboration Analysis - Subject Categories

The extended India research collaboration analysis for subject categories provides a final perspective of the nature of India collaborative research with the USA and Peoples Republic of China. The analysis determines the impact (effects) of collaboration on the overall regarded utility of the research based on article citations and associated Journal impact factors.

- As a benchmark, there is a clear ranking in the distribution of total citations for all articles; median citation for Top 10 articles; and median citation for Top 10 articles from the Top 10 Journals; between India, China and USA (in order) for all categories.

- However, the trends and rankings in the distribution of the average citation for articles with India (only), India with USA, and India with China addresses have dramatic relative shifts and are completely different. The average citations of articles with reflecting bilateral collaboration with USA or China significantly exceed the average citations of indigenous output containing only India addresses.

- There are also no clearly defined relative trends as the average citations fluctuate throughout all categories. The fluctuations are probably not random however, and are likely based on the nature of published research that is specific to each subject category.

The nature of publication in this case concerns cumulative article citation rates and journal impact factors that in general cannot be compared across technical disciplines such as applied physics and plant sciences.

Research Expenditure / Output Comparison

The final analysis of the India S&T literature assessment examined the relation between the (2005-2006) budget allocations for each India S&T Department/Ministry and the total combined categorized output from all databases

- The India Union Budget for the period (2005-2006) includes allocations and detailed descriptions of research being conducted by the primary S&T Departments/Ministries. As indicated in Table 3, the total budget allocation is approximately 17,964 crore rupees or equivalently, $ 3.6 Billion US dollars, with the majority being allocated under the Ministry of Agriculture.

- Total categorized output comprised all combined research articles from each set of SCI/SSCI, EC and INSPEC Level 4 clusters (research focus areas) identified from taxonomy analyses (Table 8). Aggregate focus areas (category headings) for all database taxonomies were used to produce research output categories for classification under the eight S&T Department/Ministry research expenditure areas.

- Using the ratio for the Department of Science and Technology (S&T) as a benchmark, the ratio of budget allocation percentage (9.11%) to the percentage of research articles assigned (51.88%) equaled (0.18). The "corrected" ratio for the Department of Space equals 0.29, when only space sciences are considered, approximates the ratio for S&T (0.18). The "corrected" ratio for Agricultural Research equals 1.90. Lastly, the "corrected" ratio for the Department of Atomic Energy (DAE) equals 1.57.

1 Introduction

Southeast and East Asia have become dynamic growth areas, especially in science and technology (S&T), and recent textual data mining (TDM) studies of specific technologies have indicated dramatic growth in research output production by from some countries in the Asian region. As a result, we have started to adopt a national view of research output from individual countries including India and the Peoples Republic of China.

A preceding assessment of India's research literature (Ref: 1) was performed that identified the S&T core competencies of India, and provided a comparison of representative competencies with other select countries. A similar study was conducted that provided comparisons of the structure and infrastructure of Chinese and Indian S&T research literature (Ref: 2). The TDM process employed in both studies is based on use of computational linguistics (document clustering) to identify main research thrusts, volume of research output in main research thrusts, and the relative quality of select major thrusts. Aggregate publication and citation bibliometrics were obtained and hierarchical research taxonomies, based on document clustering, were generated for both Indian and Chinese research. Additionally, bibliometrics and thematic trends were tracked over the past two decades.

1.1 Objectives

The primary objective of this study is to provide an update to the preceding assessment of Indian S&T research literature (Ref: 1). The preceding study was based on a sampling of India publication output in the Science Citation Index/ Social Science Citation Index (SCI/SSCI) for the period (2005). For the present study, three source databases were used for the analyses including:

1. Institute for Scientific Information (ISI), Web of Science, Science Citation Index (SCI) Expanded (includes Social Sciences Citation Index (SSCI))
2. Engineering Village, Engineering Compendex (EC)
3. Engineering Village, INSPEC

The raw data retrieved for analysis consists of extracted journal publications (including the fields of authors, titles, journals, author addresses, author keywords, abstract narratives, and references cited for each paper) obtained by searching the Web version of the SCI/ SSCI, EC and INSPEC databases. Specifically, research articles that contained at least one author with an India address were retrieved from each database for the period (2005-2006). Since the previous assessment was based on publications obtained from the SCI/SSCI database (2005), additional emphasis is placed herein on results obtained from both EC and INSPEC databases. The retrieved research articles were then analyzed to present two types of results comprising bibliometrics and taxonomies. Bibliometrics provided an indication of the technical infrastructure (prolific authors, journals, institutions, citations), while taxonomies provided an indication of major technology thrusts and their relationships.

An additional objective of the present study was to investigate new analysis methods for use in identifying temporal trends of significant research-related parameters and provide a context in which to interpret India's present research output status. The study also provides an independent assessment of the current TDM process with regards to raw textual data retrieval, storage, and processing requirements. Provide recommendations for improving and expediting the overall TDM process.

1.2 Background

This section provides summarized background information on the overall approach used in the preceding and present studies to assess India's S&T literature. The current approach combines three concepts including: 1) Core competency determination, 2) Country technology assessments, and 3) TDM assessments, as described in the following paragraphs. This section also provides updated information on India's S&T organization, and total budget allocations to various S&T Departments and Ministries for the period (2005-2006).

1.2.1 Core Competency Determination

In the preceding report, a national research core competence is defined as a technical area that is characterized by five primary features:

1. Contains a critical mass of researchers;
2. Consists of coordinated and synchronized sub-disciplines;
3. Produces high utility/quality output;
4. Offers unique national capabilities; and
5. Contains a visible fraction of research investment.

A national research core competence is therefore a synergy of individual expertise that is aggregated and coordinated over multiple technical disciplines that can be expressed as a national research strategic investment. The textual data mining approach used in the preceding report addressed only a sub-set of the above primary features to assess potential Indian research competencies. This was achieved through the identification of India's main research thrusts, volume of research output in main research thrusts, and relative utility and quality of selected major research thrusts.

1.2.2 Country Technology Assessments

National S&T core competencies represent a country's strategic capabilities in S&T. Knowledge of country core competencies is important for several reasons including:

- Awareness of priority technical areas for joint commercial or military ventures;
- Assessment of a country's military potential; and
- Knowledge of emerging areas to avoid commercial or military surprise.

Obtaining such global technical awareness, especially from the literature, is difficult for multiple reasons:

- Much science and technology performed is not documented,
- Much documented science and technology is not widely available,
- Much available documented science and technology is expensive and difficult to acquire,
- Few credible techniques exist for extracting useful information from large amounts of science and technology documentation (Kostoff, 2003).

Most credible country technology assessments must be based on combined personal visitations to the country of interest, supplemented by copious reading of technology reports from that country. The more credible and complete evaluation processes will focus on selected technologies from a particular country, and provide in-depth analysis.

1.2.3 Textual Data Mining Technology Assessments

Text mining approaches have been developed to extract useful information from the global science and technology literature for the past decade (e.g., Kostoff (1997), Kostoff and DeMarco (2001a), Kostoff et al (1998a, 1999, 2000a, 2000b, 2001b, 2002, 2004a, 2004b, 2004c, 2005a, 2005b, 2005c, 2005d, 2006a, 2006b, 2006c, 2006d)). These studies have typically focused on a technical discipline, and examined global S&T efforts within this discipline. It is the premise that such approaches, with slight modification, could be adapted to identifying the core S&T competencies in selected countries or regions, including estimation of the relative levels of effort in each of the core technology areas. It is also the premise that coupling of the text data mining approach with advanced country technology assessment approaches would amplify the strengths of each approach and reduce current limitations. The textual data mining component of this hybrid process would be performed initially to identify:

- Key core competencies and technology thrusts in the country of interest
- Key interdisciplinary thrusts
- Approximate levels of efforts in technology-specific competency areas and in interdisciplinary areas
- Highly productive researchers
- Highly productive Centers of Excellence, including those not well known
- Highly cited researchers

Once the key technologies, researchers, and Centers of Excellence have been identified, then country (site) visitation strategies could be developed. A key step in this hybrid process would be demonstration of the ability of textual data mining to identify the targets of interest with reasonable precision in a timely and cost effective manner. These three driving parameters (performance, time, and cost) could be traded-off against each other to provide a balance acceptable and tailored to a variety of potential customers.

1.2.4 Indian Science and Technology System

This section summarizes the S&T system within India. A much more comprehensive and thorough treatment is presented in Appendix A. The current S&T infrastructure in India is a complex and multi-layered S&T system of science and science administration consisting of: governmental agencies, autonomous research institutions, universities, and industry, both in the public & private sector. In general, the S&T system can be classified under the following sectors as illustrated in Figure 1.

1. Central (federal) Government Departments
2. State (provincial) Government Departments
3. Central Socio-economic Ministries,
4. In-house R&D in private industry
5. Non-governmental organizations (NGOs), and
6. Independent research institutes.

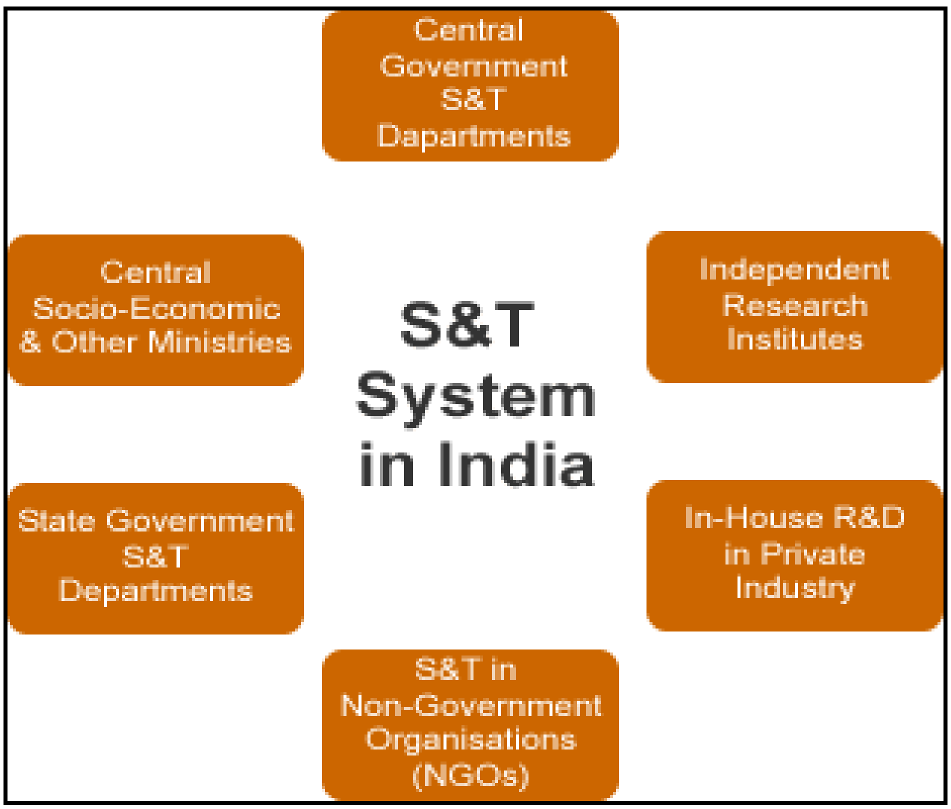

Figure 1. India Science and Technology (S&T) Infrastructure

Table 1 lists the estimated 2,899 scientific institutions to be conducting R&D activities in India (Ref. 1) that includes research institutes under other government Ministries (Steel, Power, Railways, etc.).

TABLE 1. SCIENTIFIC INSTITUTIONS UNDER DIFFERENT S&T SECTORS

S&T Sector	Number of Scientific Institutions
Central Government: R&D Institutions/laboratories	**545***
State Government: R&D Institutions/Joint Sector Companies/Research Stations	**777**
Universities (including 39 Deemed Universities; 11 Institutions of national importance)	**226**
In-house R&D units of Private Sector and Non-Profit Research Institutions	**1351**
Total	**2899**

* Source: S&T Data Book, 2000

Within the Central Government, S&T is mainly the responsibility of the Ministry of Science and Technology (Ref. 3). Central government S&T departments/agencies are the main instruments for providing resources, defining priorities, and are responsible for attainments of targets in S&T in different sectors. Figure 2 depicts the six primary S&T departments currently functioning under the auspices of Central Government including:

1. Department of Science and Technology (DST)
2. Department of Biotechnology (DBT)
3. Department of Scientific & Industrial Research (DSIR) with its vital Council for Scientific and Industrial Research (CSIR and two public enterprise NRDC and CEL)
4. Department of Atomic Energy (DAE)
5. Department of Space (DOS) and
6. Department of Ocean Development (DOD)

In addition, to these departments, there are six Central government S&T agencies including:

1. Ministry of Defense - Defense Research and Development Organization (DRDO)
2. Ministry of Non-conventional Energy Sources (MNES)
3. Ministry of Agriculture - Indian Council of Agricultural Research (ICAR)
4. Ministry of Communication & Information Technology (MCIT)
5. Ministry of Environment & Forests (MEnF)
6. Ministry of Health and Family Welfare - Indian Council of Medical Research (ICMR)

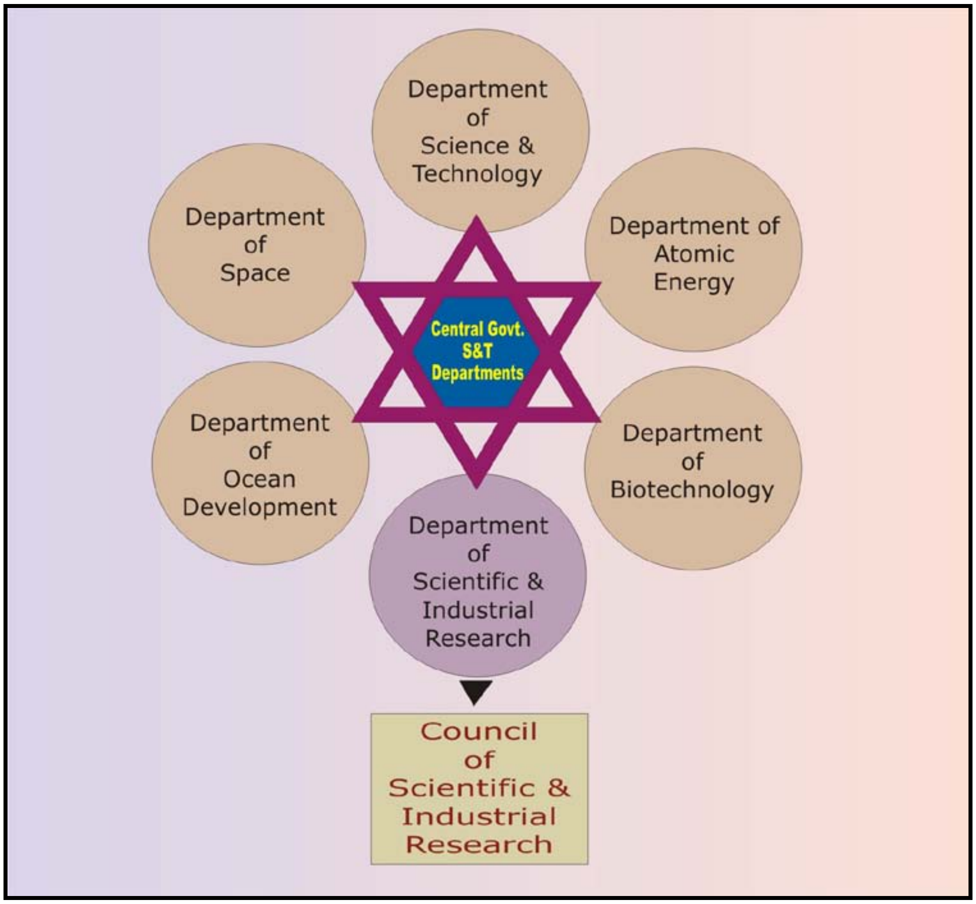

Figure 2. Central Government Science and Technology (S&T) Departments

The Department of Science and Technology (DST), depicted in Figure 3, is primarily responsible for the formulation and implementation of S&T policies, identification and promotion of thrust areas of research in different sectors of S&T; technology information, forecasting and assessment; international collaboration, promotion of science and society programs; and overall coordination of S&T activities within India. DST has recently identified fields of Research in High Priority Areas (RHPA) including nano-materials, carbon chemistry, photochemistry, neuroscience, plasma research programs, climate research, non-linear dynamics, and liquid crystals (Ref. 4). Detailed descriptions of DST and the other eleven primary S&T departments and agencies currently functioning under the auspices of Central Government is included in Appendix A.

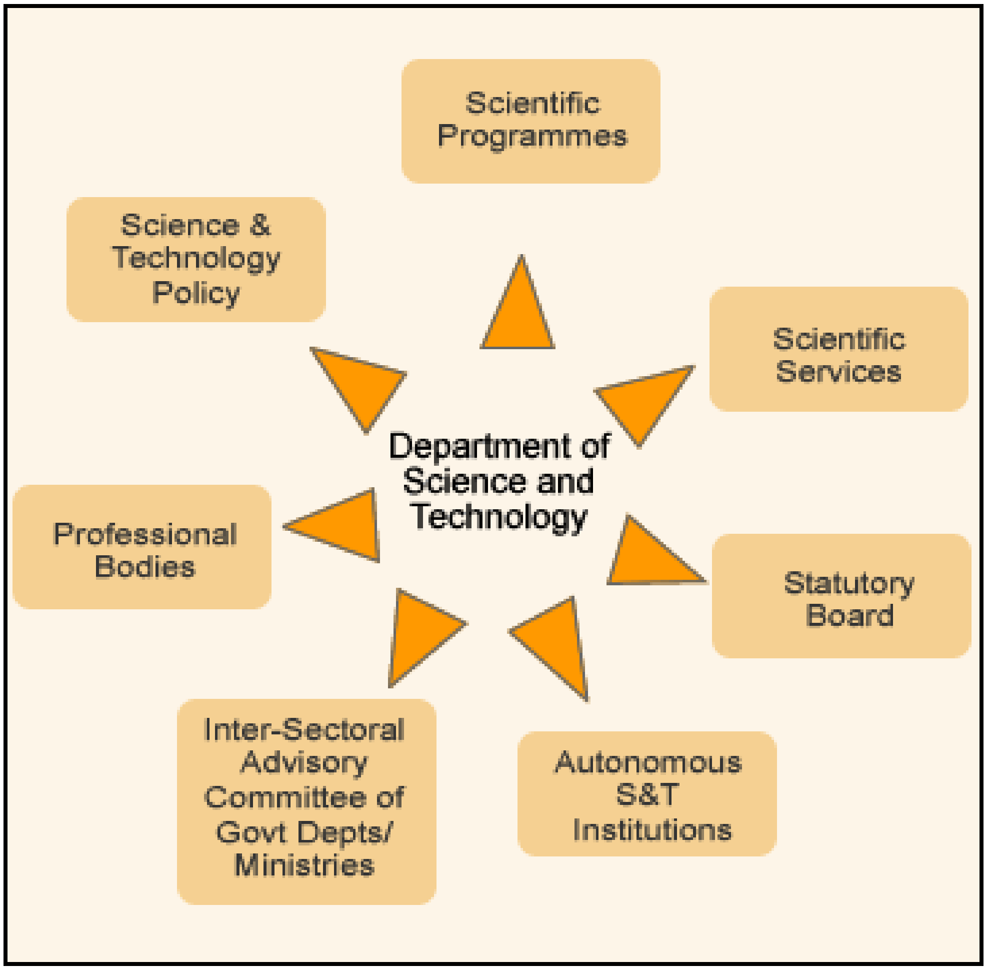

Figure 3. Central Government Department of Science and Technology (DST)

Table 2 lists the number of institutes (including laboratories and affiliated research centers) under DST and other primary central government S&T departments and agencies.

TABLE 2. LABORATORIES UNDER PRIMARY S&T DEPARTMENTS AND AGENCIES

S&T Department / Agency	Number of Institutes
Department of Science & Technology (DST)	**17**
Department of Atomic Energy (DAE)	**16**
Department of Space (DOS)	**8**
Department of Biotechnology (DBT)	**7**
Department of Ocean Development (DOD)	**15**
Indian Council for Agriculture Research (ICAR)	**84**
Defense Research & Development Organization (DRDO)	**50**
Council for Scientific & Industrial Research (CSIR)	**39**
Indian Council for Medical Research (ICMR)	**27**

The Indian S&T system also comprise the Indian Institutes of Technology (IITs) that are autonomous engineering and technology oriented institutes of higher education established and declared as Institutes of National Importance by the Government of India. Currently, there are seven (7) IITs located at Kharagpur, Mumbai (Bombay), Chennai (Madras), Kanpur, Delhi, Guwahati, and Roorkee, listed respectively in order of establishment. Several IITs were established with financial assistance and technical expertise from UNESCO, Germany, the United States, and Russia, and there are current plans to establish three additional IITs in Rajasthan, Bihar and Andhra Pradesh, increasing the total number to ten (10). The success of these IITs has led to establishment of similar institutes performing research in other fields, including the National Institutes of Technology, the Indian Institutes of Management and the Institutes of Information Technology (IIIT) (Ref. 5).

National Institutes of Technology (NITs) are premier colleges of engineering and technology education in India. They were originally called as Regional Engineering Colleges (RECs). In 2002, the Union Ministry of Human Resource Development, Government of India, decided to upgrade, in phases, all the original 17 Regional Engineering Colleges (RECs) as National Institutes of Technology (NITs), on the lines of the prestigious Indian Institutes of Technology (IITs). These institutes are rated just next to the IITs in terms of student quality, research and placements. There are currently 20 NIT's, the latest being NIT, Agartala. Their locations are deliberately scattered throughout in every major state of India for regional development. The individual NITs after the introduction of the NIT Act will function as autonomous universities and draft their own curriculum and functioning policies (Ref. 6).

The Indian Institutes of Science Education and Research (IISER) are a group of premier institutes being created by the Government of India to promote education and research in the sciences. Five IISER's have been currently planned across the country in the following locations: Kolkata in West Bengal, Pune in Maharashtra, Mohali in Punjab, Bhopal in Madhya Pradesh and Thiruvananthapuram in Kerala [1]. The financial outlay for each IISER is approximately Rs 500 crore for the first five years. Another sister research institution, the National Institute of Science Education and Research (NISER) is being established in Bhubaneswar, Orissa. Although NISER will be identical to the IISERs in all respects, with only a slightly higher initial outlay of rupees 750 crores. However, it will be administered by the Department of Atomic Energy instead of the Human Resource & Development ministry (Ref. 7)

The India Union Budget for the period (2005-2006) includes allocations and detailed descriptions of research to be conducted by the primary S&T Departments/Ministries listed in Table 3. As indicated, the total budget allocation is approximately 17,964 crore rupees or equivalently, $ 3.6 Billion US dollars, with the majority being allocated under the Ministry of Agriculture. Appendix A provides a complete description of the eight listed primary S&T Departments/Ministries including descriptions of their affiliated research centers (e.g., institutions, laboratories, universities). It should be noted that Section 5 (Research Expenditure/ Output Comparison) also provides an analysis that examines the relation between the listed budget allocations for each S&T Department/Ministry and the total combined categorized output from all three databases. Specifically, the total combined categorized output is derived from detailed taxonomy (document clustering) analyses of all research articles retrieved from the SCI/SSCI, EC and INSPEC databases (2005-2006).

TABLE 3. INDIA S&T DEPARTMENT/MINISTRY BUDGET ALLOCATION (2005-2006)

S&T Department/Ministry	Budget Allocation (2005-2006) (crore rupees)*	% Budget Allocation
MINISTRY OF SCIENCE & TECHNOLOGY		
Department of Science & Technology (DST)	1636	9.11%
Department of Scientific & Industrial Research (DSIR)	1557	8.67%
Department of Biotechnology (DBT)	459	2.56%
Department of Space (DOS)	3148	17.52%
Department of Atomic Energy (DAE)	2895	16.12%
Department of Ocean Development (DOD)	377	2.10%
Department of Health - Medical Education Training & Research	1361	7.58%
MINISTRY OF AGRICULTURE		
Department of Agriculture and Cooperation	4589	25.55%
Department of Agricultural Research and Education	1942	10.81%
Totals	17964	100%
* 1 Indian Rupee (INR) = 0.02 US Dollars * 1 crore Rupee = 10 million Rupees		

The next section of this report (Section 2) discusses the approach and results related to the bibliometrics and computational linguistics of India's research output. These computations provide the technical infrastructure and structure of India's research literature.

2 Overall Approach

In general, two major types of information are required for a country S&T core competency assessment. The first type is technical infrastructure, which encompasses the prolific authors and affiliations, prominent cited journals, and the most cited research articles. The second type of information is associated with technology thrusts, and the relationship among the thrusts. This present study focused on obtaining both types of information, and as such, two types of analysis results are presented, bibliometrics and taxonomies. Bibliometrics provide an indication of the technical infrastructure, while taxonomies provide an indication of major technology thrusts and their relationships.

For the present study, three source databases were used for the analyses including:

1. Institute for Scientific Information (ISI), Web of Science, Science Citation Index (SCI) Expanded (includes Social Sciences Citation Index (SSCI))
2. Engineering Village, Engineering Compendex (EC)
3. Engineering Village, INSPEC

The raw data retrieved for analysis consists of selected journal records (including the fields of authors, titles, journals, author addresses, author keywords, abstract narratives, and references cited for each paper) obtained by searching the Web version of the SCI/ SSCI, EC and INSPEC for articles that contained at least one author with an India address. The previous assessment was based primarily on research output literature obtained from the SCI/SSCI database for the year 2005 therefore additional emphasis is placed on results obtained from both EC and INSPEC databases.

The present study provides an update of India's S&T performance based on research output (sample records) obtained over the period (2005-2006), in addition to selected literature over the period (1980-2005) in intervals (bands). The interval data was obtained to update the previously performed temporal trend analyses. The total number of extracted records from each database for the (2005-2006) period was as follows: SCI/SSCI (52,047), EC (24,475) and INSPEC (18,988), or a grand total equal to 95,510 records. Gross bibliometrics and trends for this period are presented to place aggregate national bibliometrics analyses in perspective. Available abstract narratives were compiled and used for computational linguistics (phrase analyses, document clustering), and selected single technology bibliometrics are presented. A detailed description of the source databases, the bibliometrics approaches, and the document clustering taxonomy approach, are described in previously published related literature (Ref. 1, 2). The following sections of this report present the bibliometrics approaches and results (Section 3) and the document clustering taxonomy approach and results (Section 4).

3 Bibliometrics Approach and Results

In this section, two types of bibliometrics will be presented: 1) Publication and 2) Citation. Publication bibliometrics are counts of papers published by different entities (e.g., authors, research institutions, industry, etc.). These metrics can be viewed as output and productivity measures. They are not direct measures of research quality, although there is some threshold quality level inferred, since (in the present study) these papers are published in the (typically) high caliber journals accessed by the SCI/ SSCI, EC and INSPEC databases. Citation metrics are counts of citations to papers published by different entities. While citations are ordinarily used as impact or quality metrics, much caution needs to be exercised in their frequency count interpretation, due to numerous reasons why authors cite or do not cite particular papers.

In the present study, the focus is on the wide range of technologies being developed within India. Gross bibliometrics analyses and trends are presented first in order to place aggregate national bibliometrics analyses in perspective. Aggregate national bibliometrics analyses provide insight to the distribution of technical disciplines across major research institutions and journals. At the aggregate national level, prolific institutions, collaborative countries, journals containing most Indian papers, and the most cited journals, will be presented.

Following the overall India bibliometrics, specific themes are presented using a wider variety of bibliometrics than for the overall country. At the single technology level, most cited first authors and documents are included as well. To conduct the single-technology theme bibliometric analyses, thematic thrust areas are first identified, and research articles that address each theme are then retrieved. The bibliometrics are then performed on a theme-by-theme basis. For the present study, two themes are selected as illustrative examples for the bibliometrics in the main body of the text.

3.1 Overall India Bibliometrics

This section presents temporal publication trends, journals containing most articles, journals cited most frequently by India authors, most prolific institutions, and most collaborative countries for the aggregate India database.

3.1.1 Publication Trends

The first metric is number of records (articles) as a function of time. All research articles in the SCI/ SSCI, EC and INSPEC databases having at least one author with an India address were retrieved for the period (1980-2005). The select literature for this period was retrieved by both relative intervals (bands) and individual years. The relative intervals were used to allow gross comparison of additional bibliometric trend data for the period 1980–2005 associated with subject categories, author affiliations and country addresses, as it was not feasible to process this amount of data for each individual year over the entire period (1980-2005). All research articles in the SCI/SSCI, EC and INSPEC databases having at least one author with an India address were also retrieved for the period (2005-2006) to provide publication trend data for comparison to the preceding study (SCI/SSCI 2005).

It should be noted that the trends based on relative defined intervals (e.g. 80-85, 85-90, 90-95, etc.) contain some overlap of total publication data (68,753 records, or ≈ 10% of the total actual records = 652,268). Since all database literature is dynamic in nature (total articles and citations change daily), the defined intervals are used consistently throughout the present study and intended for relative analyses only, not to provide absolute data. The trends based on annual intervals (individual years) do not contain overlap and provide actual publication data.

Table 4 lists the SCI/SSCI, EC and INSPEC total article publications for the period (1980-2005) by relative intervals. Figure 4 provides a graphical illustration of the publication trend that clearly indicates a consistent increase in published articles for each database, except for the EC total articles associated with the interval (1990-1995). The total publications for all intervals over the entire period (1980-2005) equaled 721,021 articles. Due to the large number of records retrieved from each database in a given defined interval, it was not feasible to download processed records to obtain article citation data.

TABLE 4A. SCI, EC AND INSPEC (1980-2005) TOTAL PUBLICATIONS BY INTERVALS

SCI/SSCI - EC - INSPEC Total Publications (1980 - 2005) by Intervals			
Interval	**SCI/SSCI Total Articles**	**EC Total Articles**	**INSPEC Total Articles**
(1980 - 1985)	**64600**	**22728**	**28506**
(1985 - 1990)	**67416**	**22941**	**30606**
(1990 - 1995)	**73202**	**20104**	**33246**
(1995 - 2000)	**92909**	**31735**	**34612**
(2000 - 2005)	**100000**	**53360**	**45056**
Totals	**398127**	**150868**	**172026**
Grand Total	**721021**		

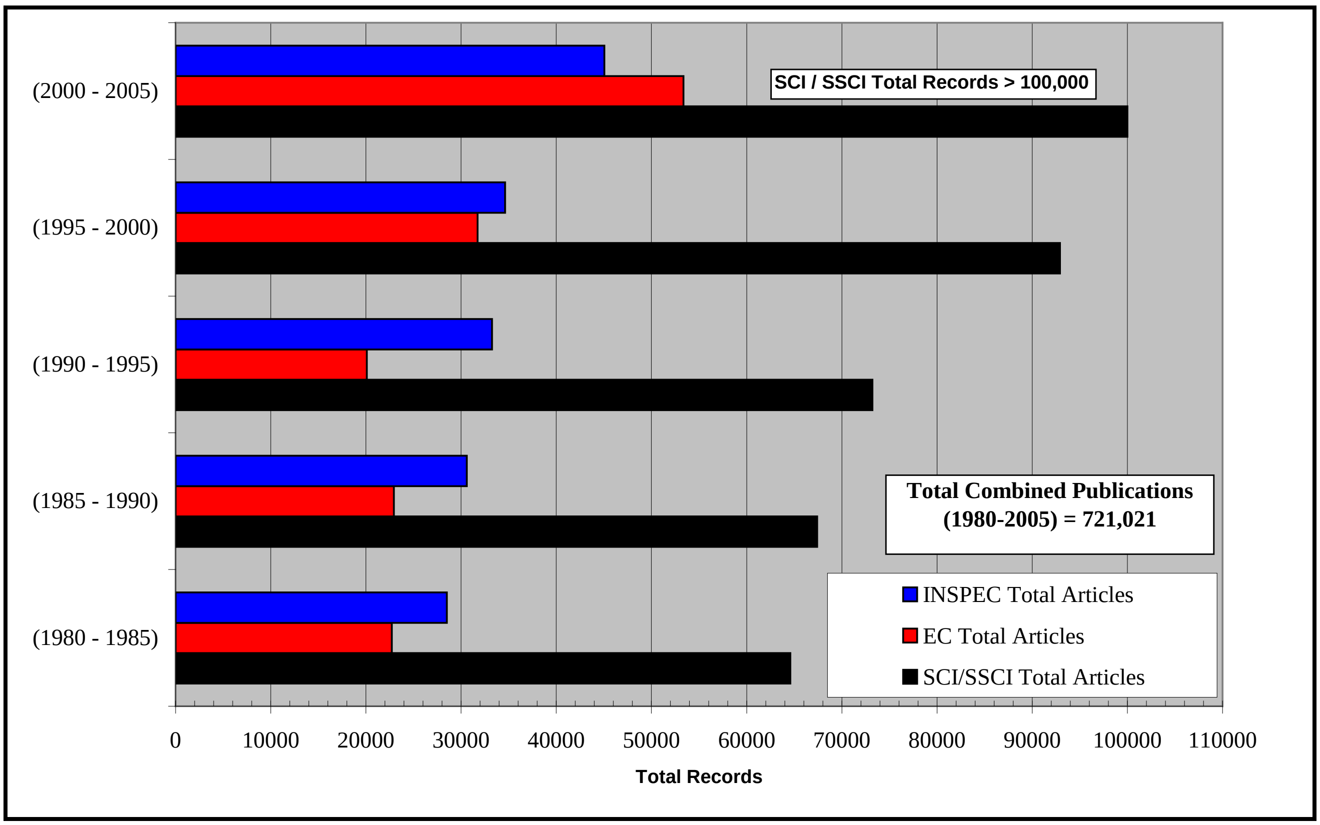

Figure 4. SCI, EC and INSPEC (1980-2005) Total Publications by Intervals

Table 5 lists the SCI/SSCI, EC and INSPEC total article publications for the period (1980-2005) by annual intervals or individual years. Figure 5 provides a graphical illustration of the publication trend that clearly indicates a consistent increase in published articles for each database, except for the EC total articles associated with the interval (1983-1992). The total publications for all intervals over the entire period (1980-2005) equaled 652,268 articles. Due to the large number of records retrieved from each database in a given defined interval, it was not feasible to download processed records to obtain comparative article citation data. Lastly, Figure 6 provides the SCI/SSCI, EC and INSPEC total article publications for the period (2005-2006).

TABLE 4B. SCI, EC AND INSPEC (1980-2005) TOTAL PUBLICATIONS BY YEARS

SCI/SSCI - EC - INSPEC Total Publications (1980-2005) by Year			
Year	**SCI/SSCI Total Articles**	**EC Total Articles**	**INSPEC Total Articles**
1980	10606	2587	4451
1981	11178	2965	4366
1982	10895	4493	4600
1983	10601	5024	5309
1984	10688	4377	5140
1985	10632	4245	4640
1986	11223	4228	4931
1987	11215	4144	5311
1988	10927	3556	4987
1989	11856	3809	5541
1990	11564	2959	5196
1991	12375	2976	5312
1992	12429	2473	5788
1993	12103	3598	5454
1994	12130	4393	5652
1995	12604	3705	5854
1996	15508	4766	5652
1997	15067	4975	5631
1998	16222	5610	5747
1999	17326	6358	5748
2000	16197	6321	5992
2001	17792	6855	5924
2002	18695	8343	7776
2003	20976	9205	7574
2004	21022	10561	8399
2005	25238	12203	9495
Totals	367069	134729	150470
Grand Total	652268		

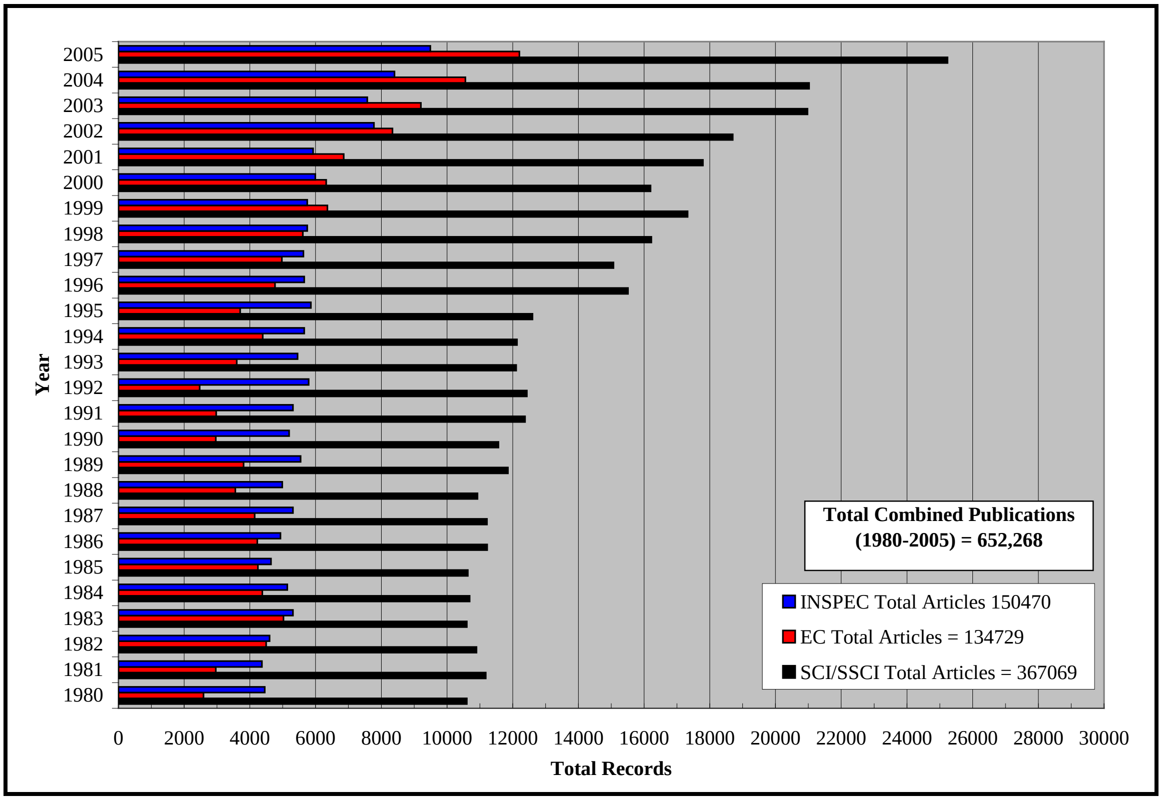

Figure 5. SCI, EC and INSPEC (1980-2005) Total Publications by Years

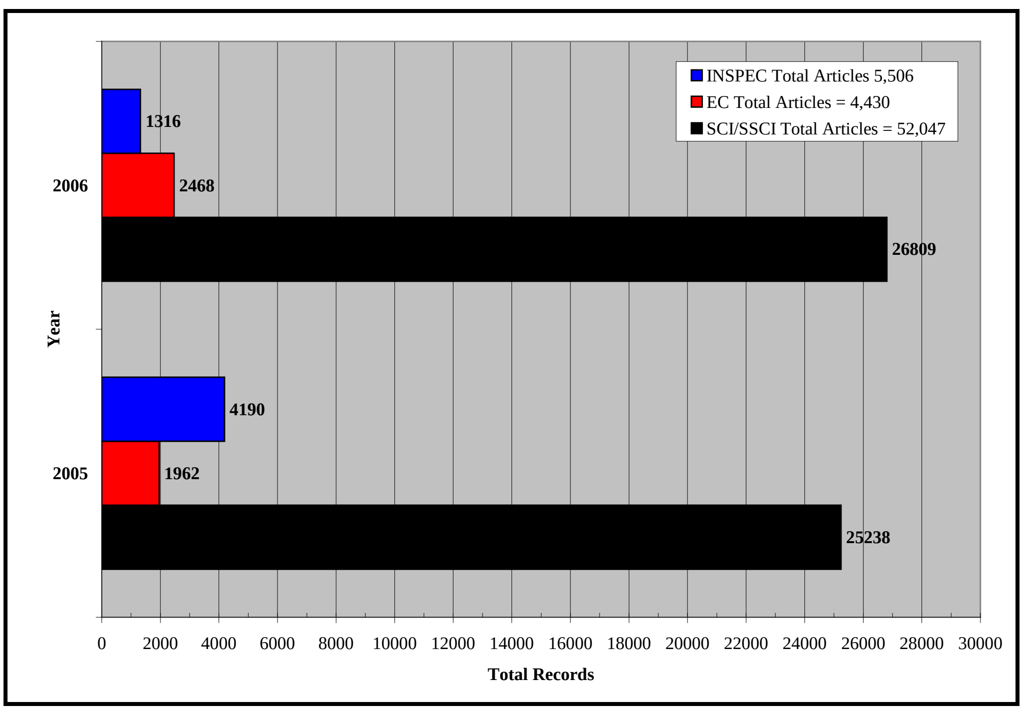

Figure 6. SCI, EC and INSPEC (2005-2006) Total Publications

The following groups of figures present additional publication trend data for the period 1980–2005 associated with subject category, author affiliation and country collaboration bibliometrics. It should be noted that the bibliometrics presented in this section are gross results that are intended to lay the framework for more detailed bibliometric analyses in subsequent sections of this report.

3.1.1.1 Publication Trends - Subject Categories

Figures 7 through 11 show the SCI/SSCI Subject Categories for the period (1980-2005), in intervals. Figure 12 shows the current SCI/SSCI Subject Categories for the period (2005-2006). A two percent (2 %) cutoff, relative to the total number of records, was used in the analysis to extract the predominant categories.

Figure 7 indicates that the predominant categories for (1980-1985) were associated with several disciplines including Chemistry, Plant Sciences, Physics, Biochemistry and Molecular Biology, Immunology, Medicine, and Biology. The percentage of records published within the Top 10 categories ranged from approximately 2.8 % (Biology) – 6.8% (Chemistry), relative to the total number of extracted records (64,600).

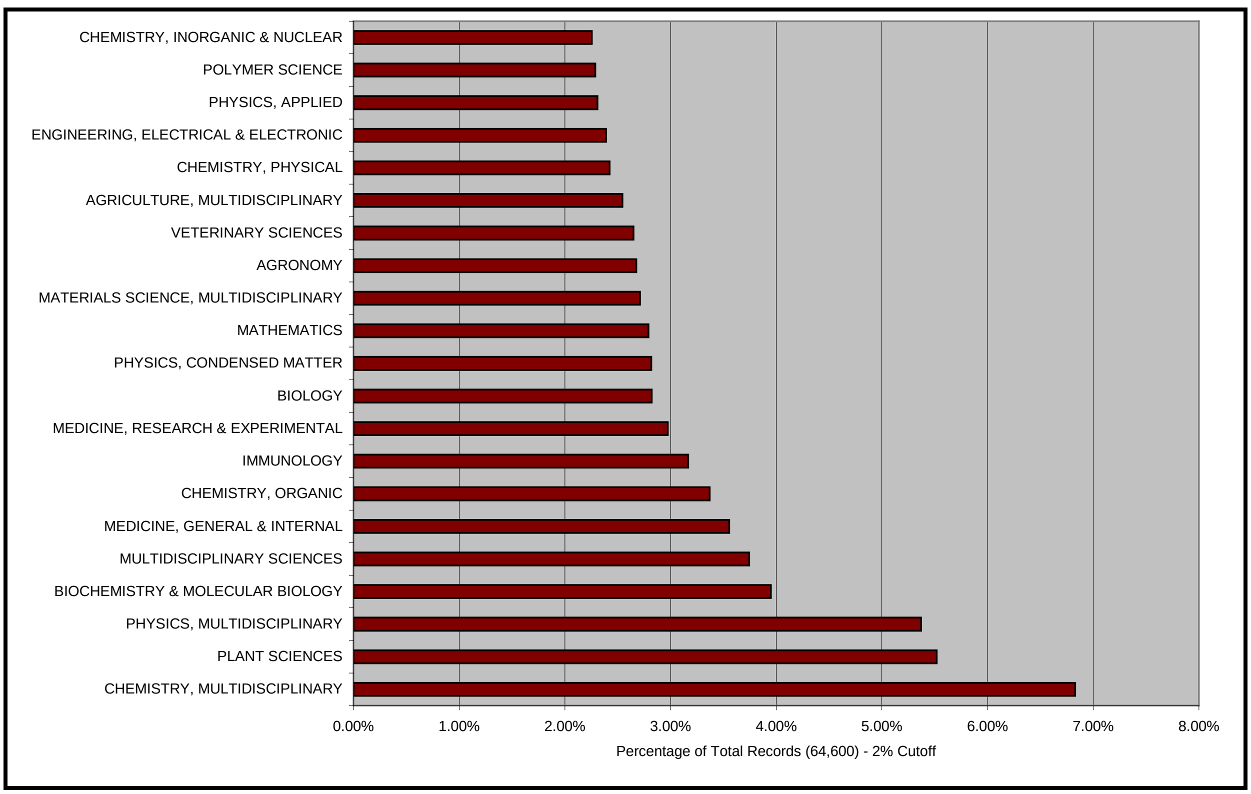

Figure 7. SCI/SSCI Subject Categories for (1980 - 1985)

Figure 8 indicates that the predominant categories for (1985-1990) were associated with several disciplines including Chemistry, Materials Sciences, Physics, Plant Sciences, Biochemistry, and Molecular Biology. The percentage of records published within the Top 10 categories ranged from approximately 2.8 % (Applied Physics) – 5.9 % (Chemistry), relative to the total number of extracted records (67,416). Note that categories related to immunology and medical disciplines are no longer listed within the Top 10 subject categories for this period.

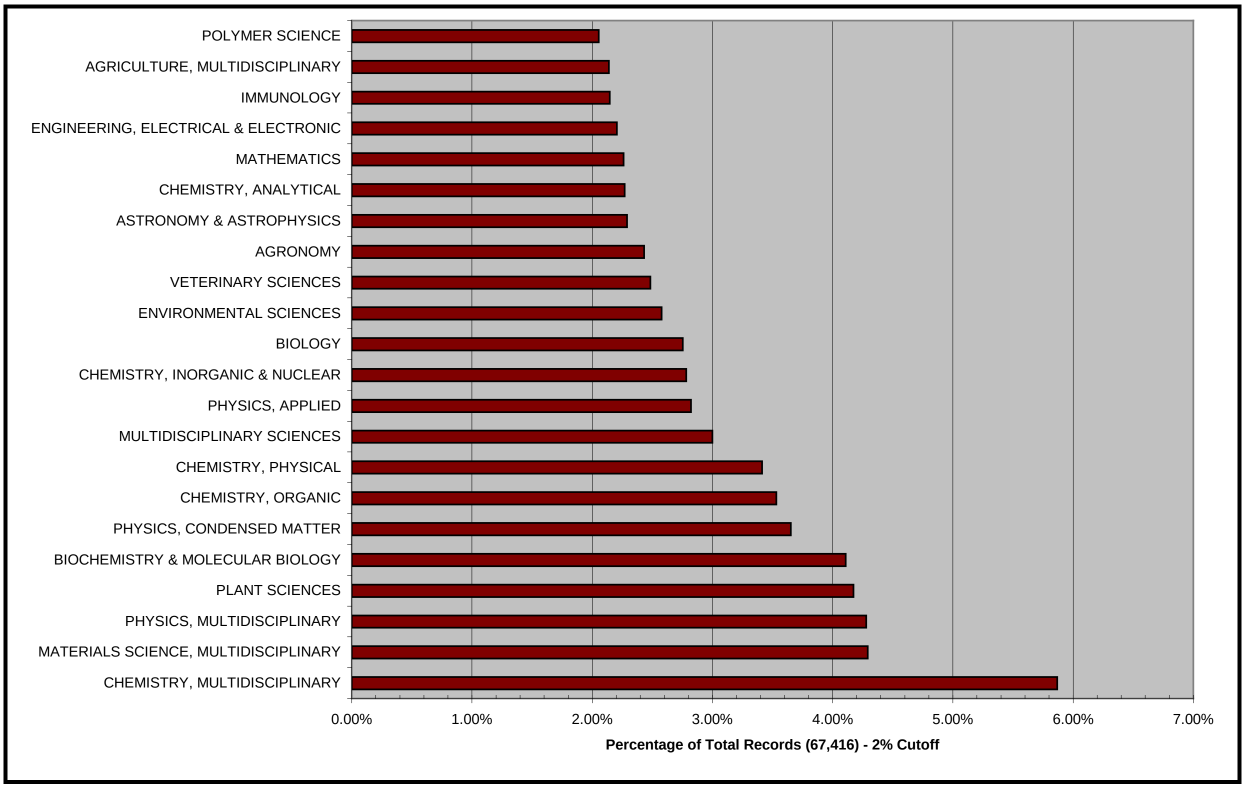

Figure 8. SCI/SSCI Subject Categories for (1985 -1990)

Figure 9 indicates that the predominant categories for (1990 - 1995) were associated with several disciplines including Materials Sciences, Chemistry, Physics, Biochemistry, and Molecular Biology and Plant Sciences. The percentage of records published within the Top 10 categories ranged from approximately 3.1 % (Inorganic & Nuclear Chemistry) – 5.9 % (Materials Sciences), relative to the total number of extracted records (73,202). Note that categories related to immunology and medical disciplines are no longer listed within the Top 20 subject categories for this period.

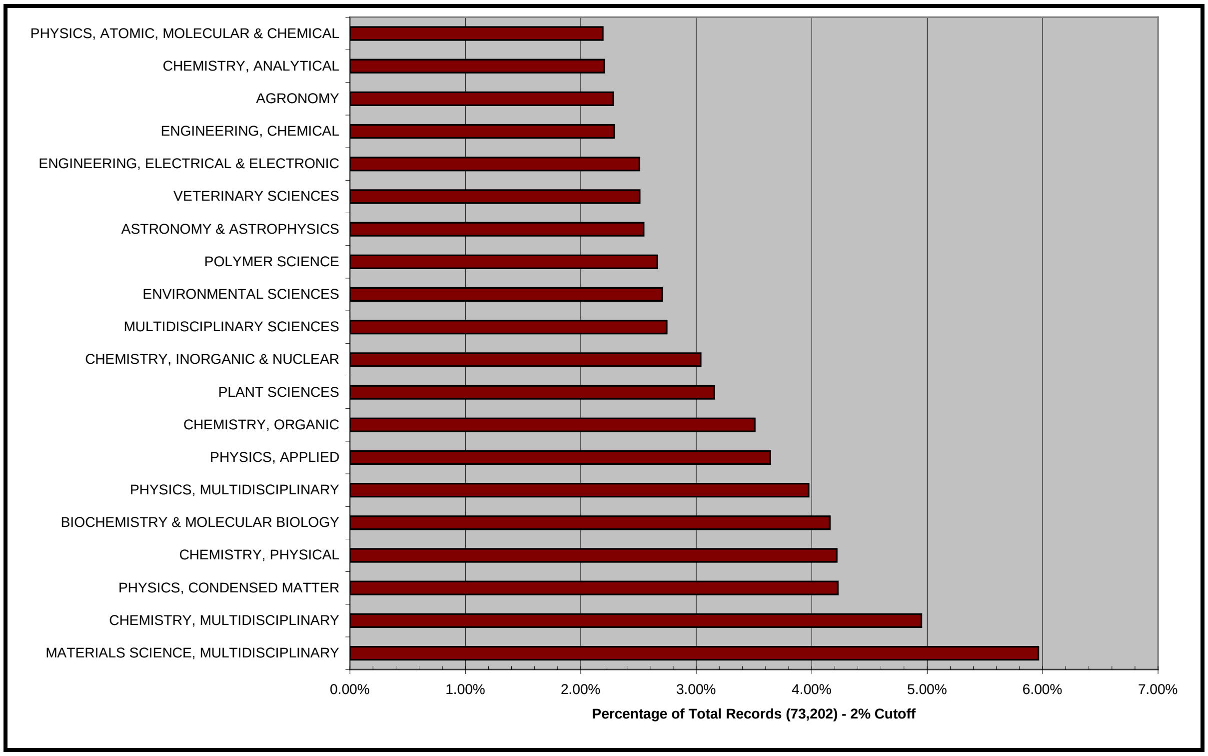

Figure 9. SCI/SSCI Subject Categories for (1990 -1995)

Figure 10 indicates that the predominant categories for (1995-2000) were associated with several disciplines including Materials Sciences, Chemistry, Biochemistry, and Molecular Biology, Physics, and Electrical/Electronic Engineering. The percentage of records published within the Top 10 categories ranged from approximately 3.0 % (Electrical/Electronic Engineering) – 6.4 % (Materials Sciences), relative to the total number of extracted records (92,909). Note that categories related to Geosciences, Agronomy, Metallurgy, and Biotechnology disciplines are now listed within the Top 20 subject categories for this period.

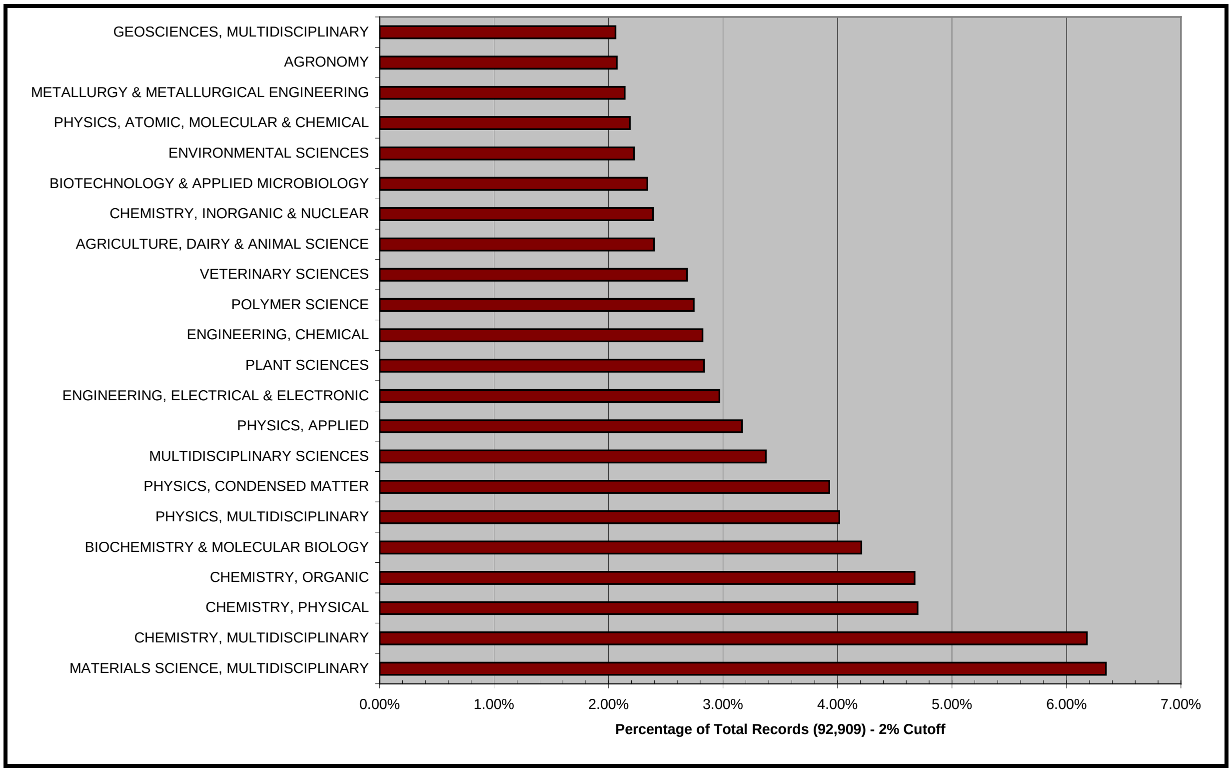

Figure 10. SCI/SSCI Subject Categories for (1995 -2000)

Figure 11 indicates that the predominant categories for (2000-2005) were associated with several disciplines including Chemistry, Materials Sciences, Biochemistry, and Molecular Biology, Physics, and Chemical Engineering. The percentage of records published within the Top 10 categories ranged from approximately 2.8 % (Chemical Engineering) – 6.8 % (Chemistry). Note that Crystallography and Agronomy is newly listed categories emerging for this period.

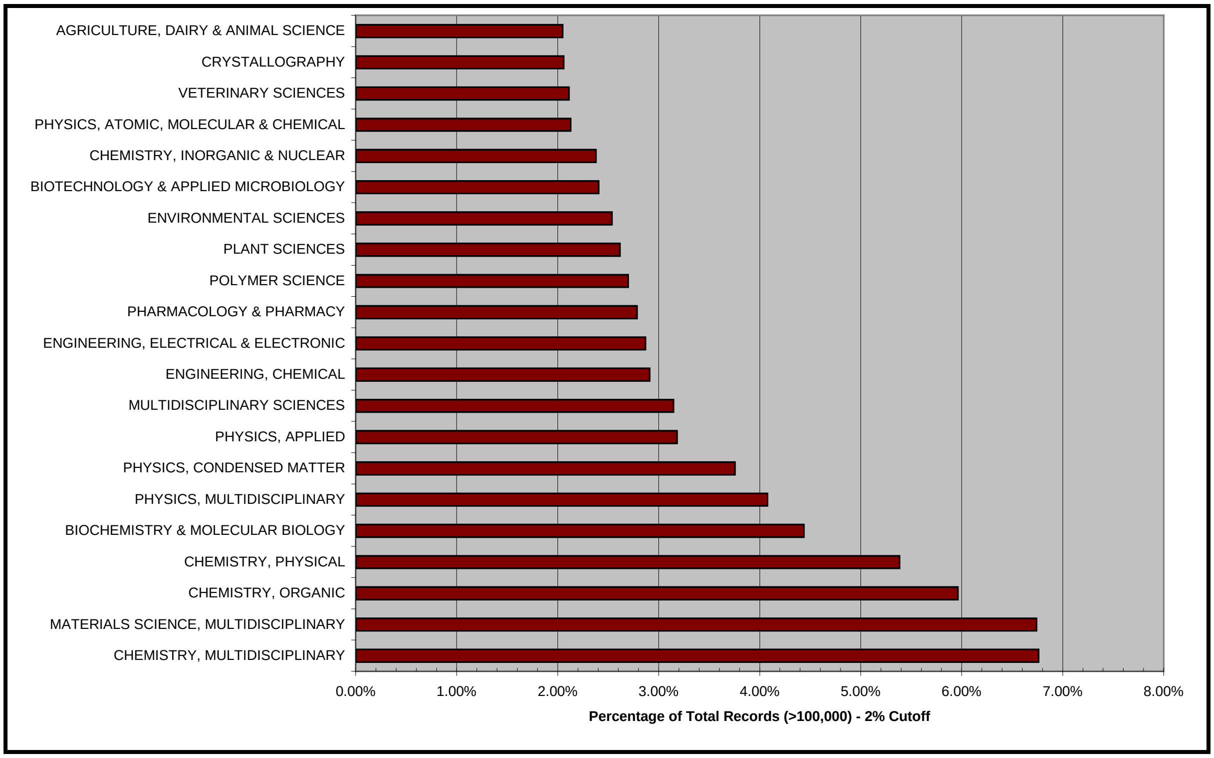

Figure 11. SCI/SSCI Subject Categories for (2000 - 2005)

Figure 12 indicates that the predominant categories for (2005-2006) were associated with several disciplines including Materials Sciences, Chemistry, Biochemistry, and Molecular Biology, Physics, Chemical Engineering, and Pharmacology. The percentage of records published within the Top 10 categories ranged from approximately 2.8 % (Pharmacology) – 6.8 % (Materials Sciences). Note that Food Science and Technology, Agricultural Research and Animal Sciences are newly listed categories emerging for this period.

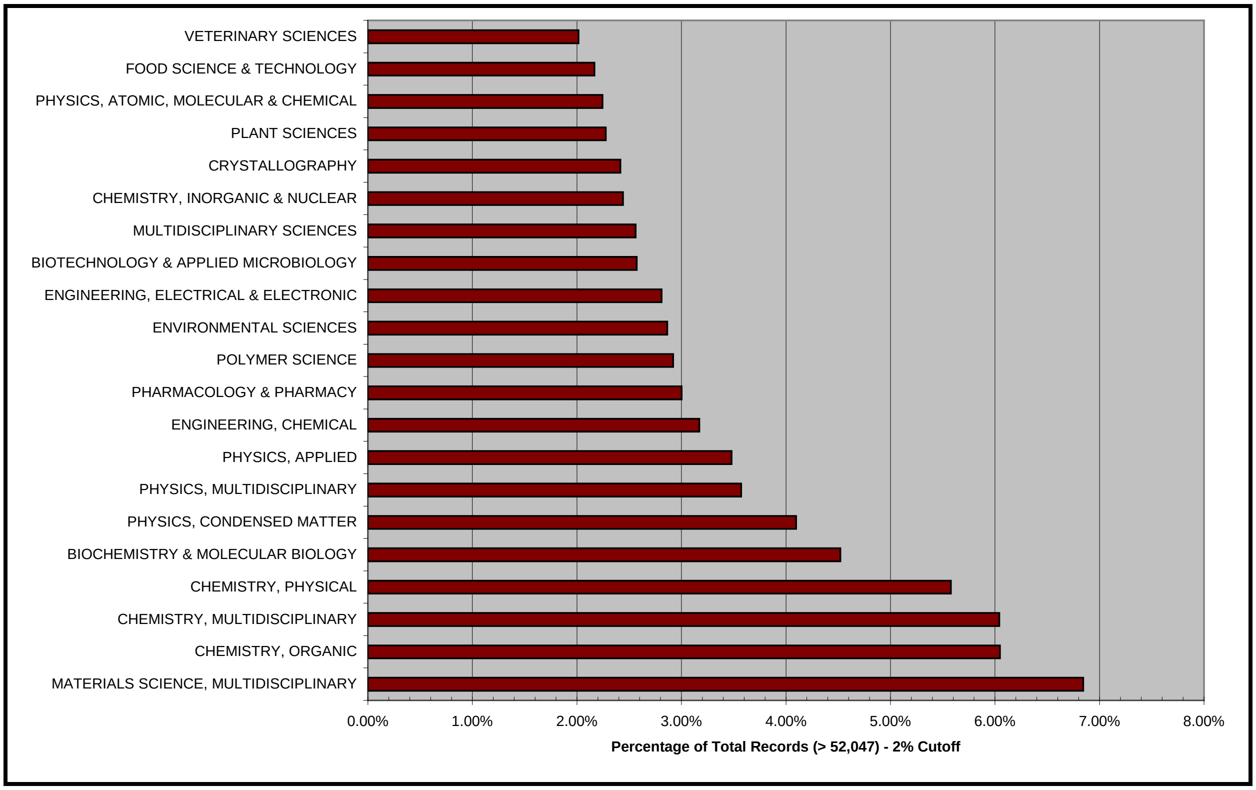

Figure 12. SCI/SSCI Subject Categories for (2005 - 2006)

3.1.1.2 Publication Trends - Author Affiliations

Figures 13 through 17 show the SCI/SSCI Author Affiliations for the period (1980 - 2005), in intervals. A one percent (1 %) cutoff, relative to the total number of records, was used in the analysis to extract the predominant Affiliations.

Figure 13 indicates that the Affiliations for (1980 - 1985) were associated with several leading Institutes, Laboratories and Universities including Indian Institute of Technology, Indian Institute of Science, Tata Institute of Fundamental Research, Bhabha Atomic Research Center, Banaras Hindu University and the University of Delhi. The percentage of records published within the Top 10 Affiliations ranged from approximately 1.3 % (Aligarh Muslim University) – 9.4 % (Indian Institute of Technology), relative to the total number of extracted records (64, 600).

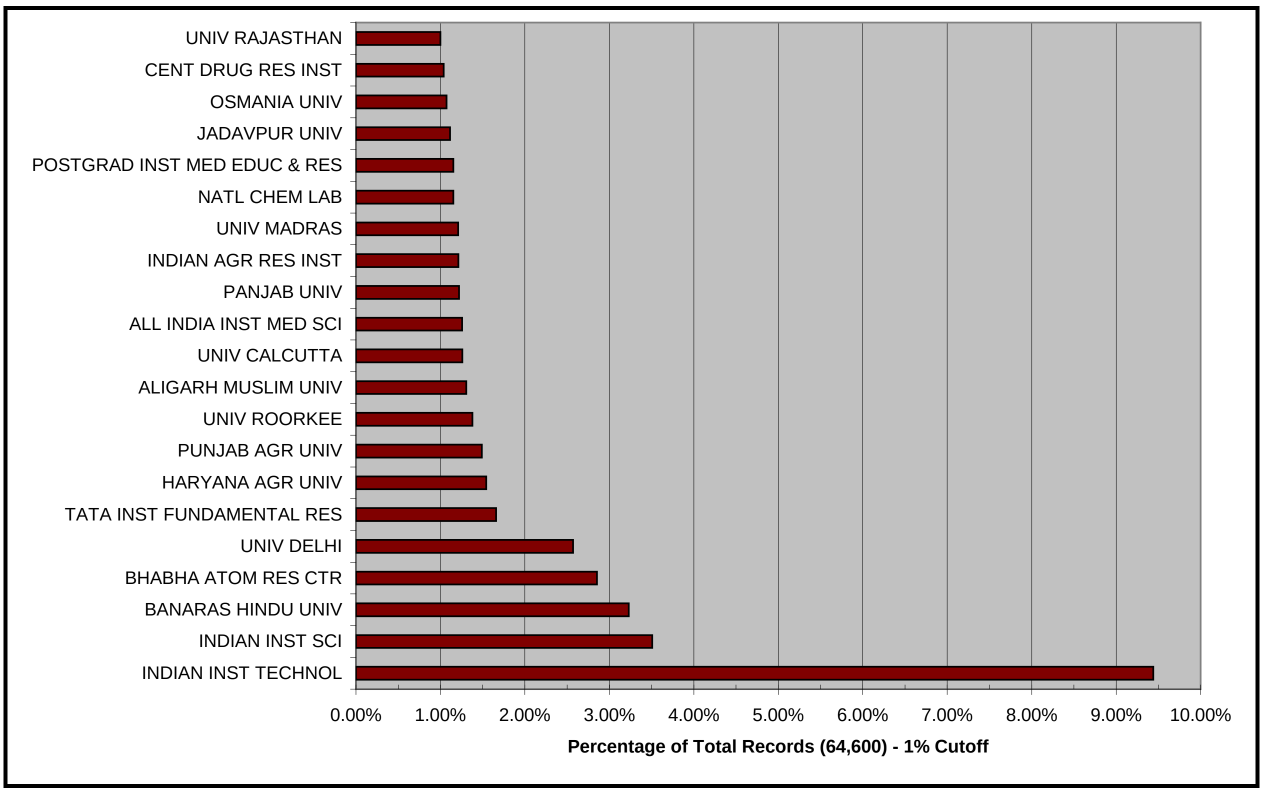

Figure 13. SCI/SSCI Author Affiliations for (1980 - 1985)

Figure 14 indicates that the Affiliations for (1985 - 1990) were associated with same leading Institutes, Laboratories and Universities as listed for (1980 - 1985), with slight change in rankings. The percentage of records published within the Top 10 Affiliations ranged from approximately 1.4 % (All India Institute of Medical Sciences) – 9.86 % (Indian Institute of Technology), relative to the total number of extracted records (67,416).

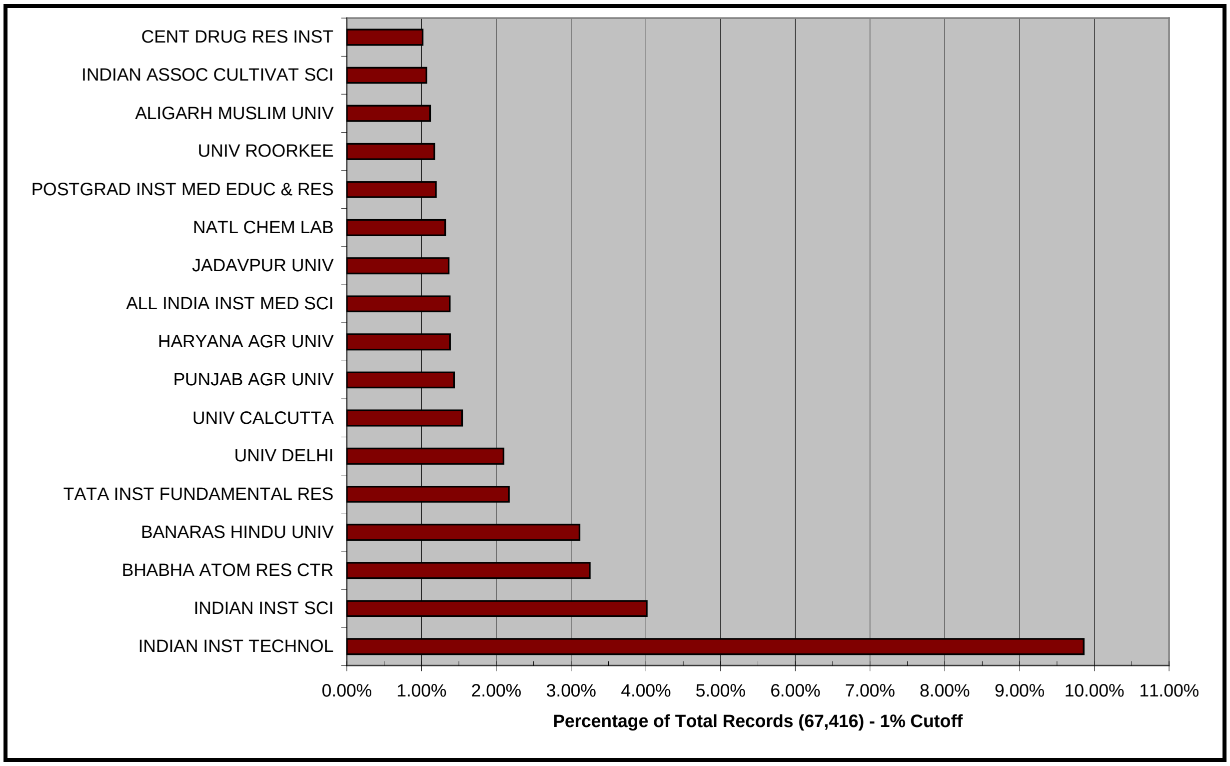

Figure 14. SCI/SSCI Author Affiliations for (1985 - 1990)

Figure 15 indicates that the Affiliations for (1990 - 1995) were associated with same leading Institutes, Laboratories and Universities as listed for (1985 - 1990), with identical rankings. The percentage of records published within the Top 10 Affiliations ranged from approximately 1.3 % (All India Institute of Medical Sciences) – 10.5 % (Indian Institute of Technology), relative to the total number of extracted records (73,202).

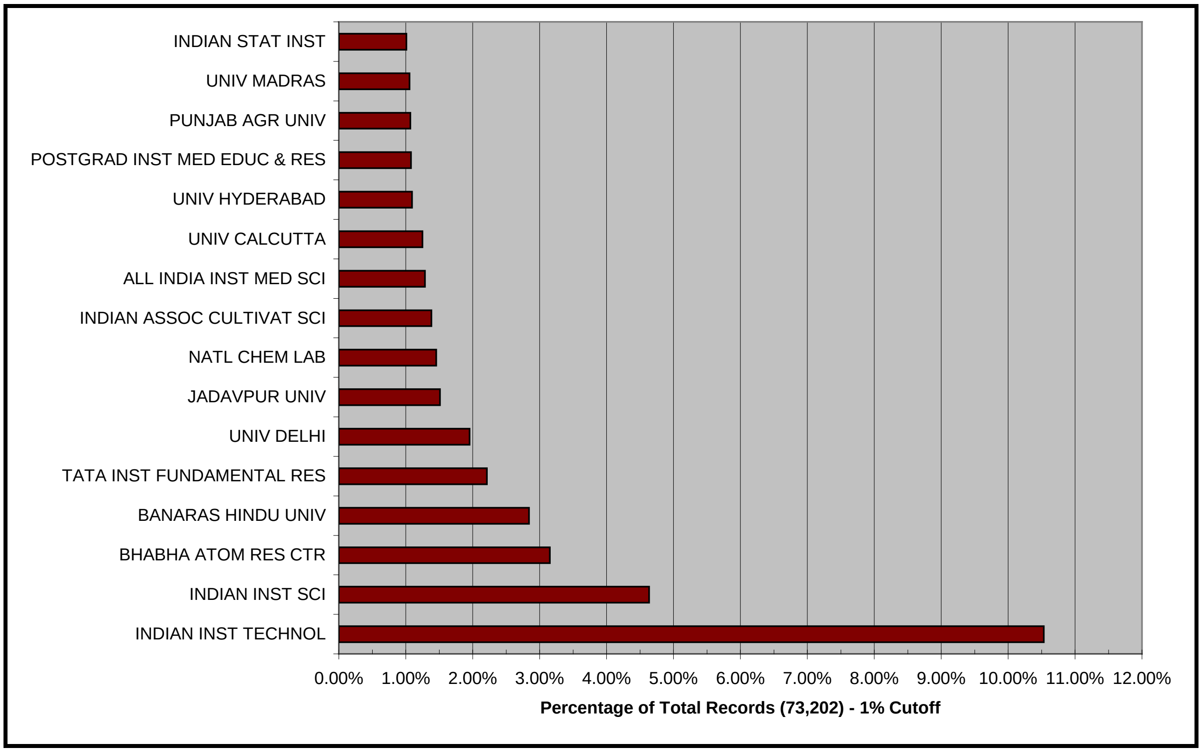

Figure 15. SCI/SSCI Author Affiliations for (1990 - 1995)

Figure 16 indicates that the Affiliations for (1995 - 2000) were associated with same leading Institutes, Laboratories and Universities as listed for (1990 - 1995), with identical rankings. Note the increase in rankings for the National Chemical Laboratory, relative to previous 5-year intervals. The percentage of records published within the Top 10 Affiliations ranged from approximately 1.4 % (Jadavpur University) – 10.6% (Indian Institute of Technology), relative to the total number of extracted records (92,909).

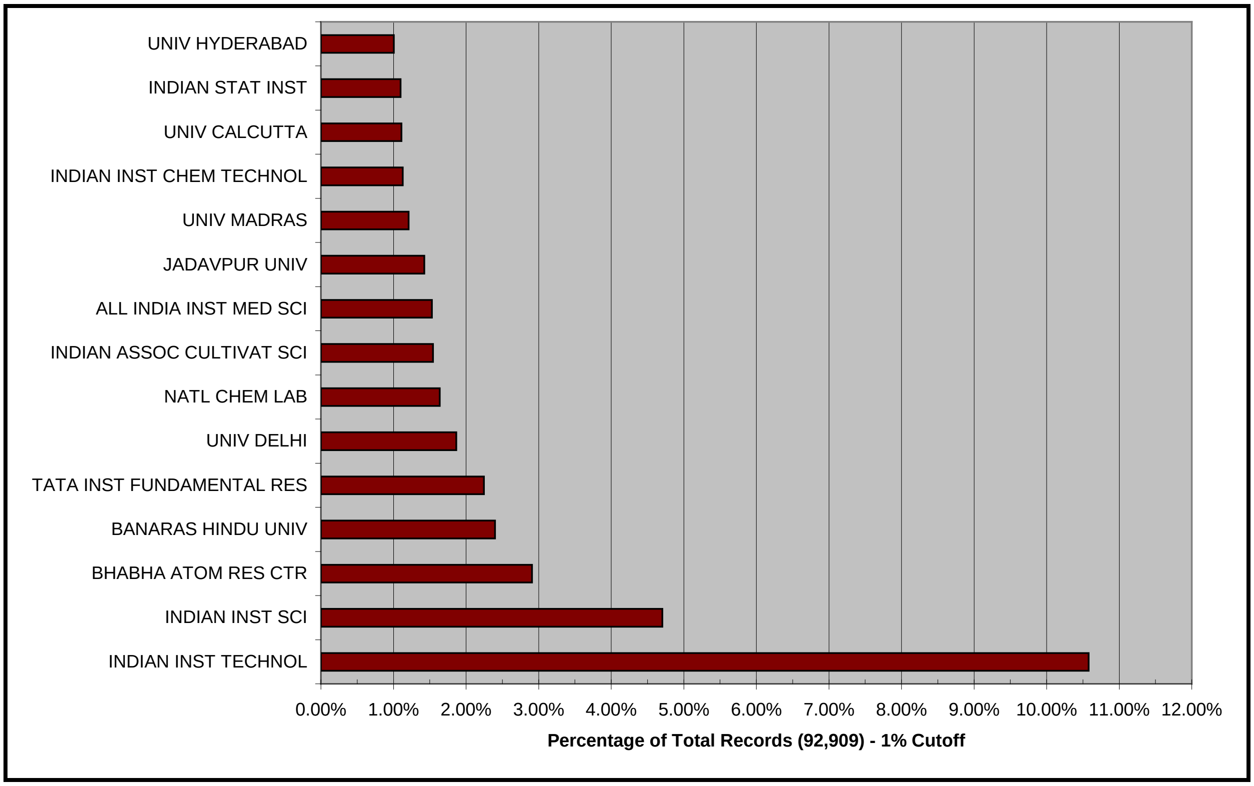

Figure 16. SCI/SSCI Author Affiliations for (1995 - 2000)

Figure 17 indicates that the Affiliations for (2000-2005) were associated with the same leading Institutes, Laboratories and Universities as listed for previous intervals, with a notable increase in rankings for the National Chemical Laboratory and the Indian Institute of Chemical Technology. The percentage of records published within the Top 10 Affiliations ranged from approximately 1.5 % (Jadavpur University) – 10.8 % (Indian Institute of Technology), relative to the total number of extracted records (>100,000).

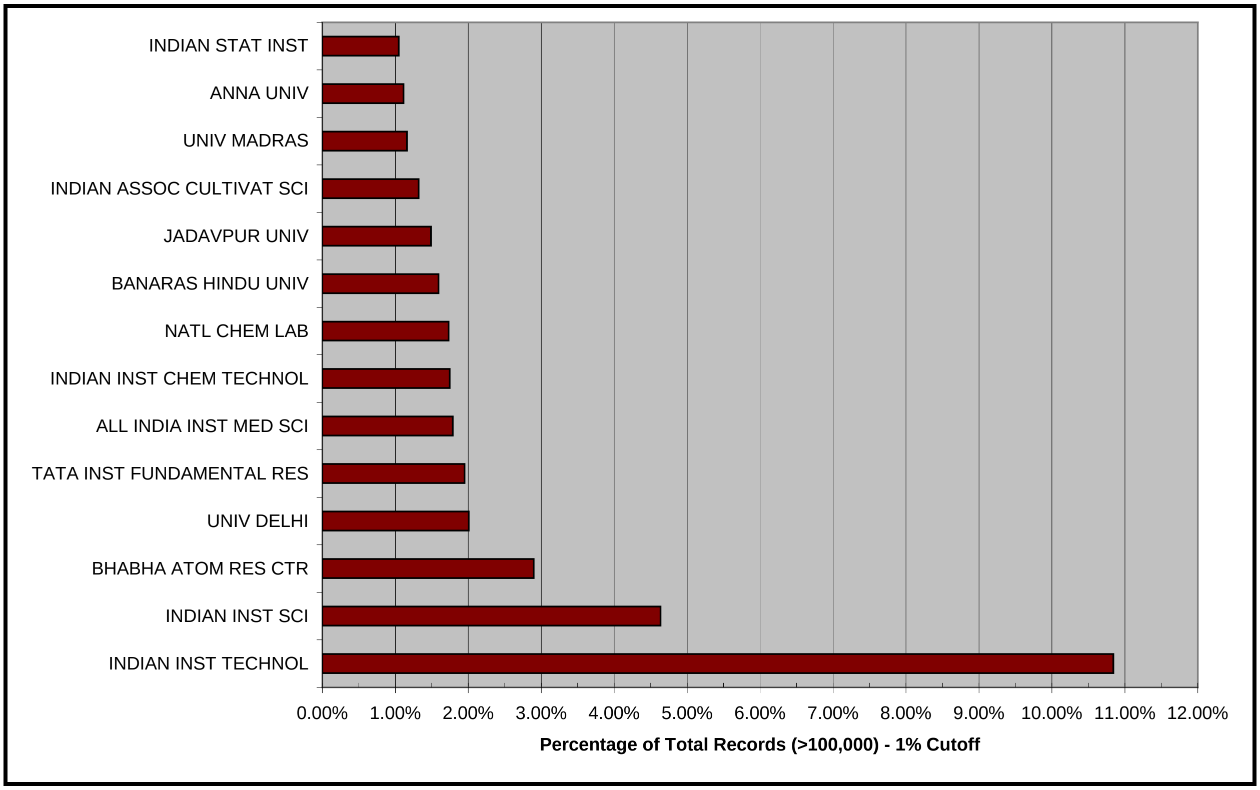

Figure 17. SCI/SSCI Author Affiliations for (2000 - 2005)

Figure 18 provides an updated list of the Top 25 SCI/SSCI Author Affiliations for the period (2005-2006). The relative rankings were essentially the same as listed for previous 5-year intervals. It should be noted that the gross bibliometric Author Affiliation data displayed in Figure 18 was produced or extracted using the SCI/SSCI Analyst Tool and serves as general information, since the data does not reflect the exact location of the affiliation throughout India. The percentage of records published within the Top 10 Affiliations ranged from approximately 1.5 % (Banaras Hindu University) – 12.4 % (Indian Institute of Technology), relative to the total number of extracted records (52,047).

Since several affiliations, such as the Indian Institute of Technology, have numerous facilities located throughout India, the EC data for these entities were grouped or "rolled-up" to allow comparison with SCI/SCCI data for the same period. Figure 19 provides an updated list of the Top 25 EC Author Affiliations for the period (2005-2006). As shown, several of the higher ranked Affiliations are associated with the same leading Institutes, Laboratories and Universities listed for the SCI/SSCI database. However, as anticipated, there is a notable inclusion of EC Affiliations involved in more applied research and technology development, attributed to the primary EC record topics comprising chemical and process engineering, computers and data processing, applied physics, electronics and communications, civil, mechanical and materials engineering, as well as narrower subtopics within all these major fields. Some of the more notable Affiliations include the Central Electrochemical Research Institute, National Physical Laboratory, National Metallurgical Laboratory, Crystal Growth Center - Anna University, and the Defense Metallurgical Research Laboratory. It should be noted that the bibliometric Author Affiliation data displayed in Figure 19 was produced using gross EC record statistics. The percentage of records published within the Top 25 Affiliations ranged from approximately 0.1 % (National Geophysical Research Institute) – 6.6 % (Indian Institute of Technology), relative to the total number of extracted records (24,475).

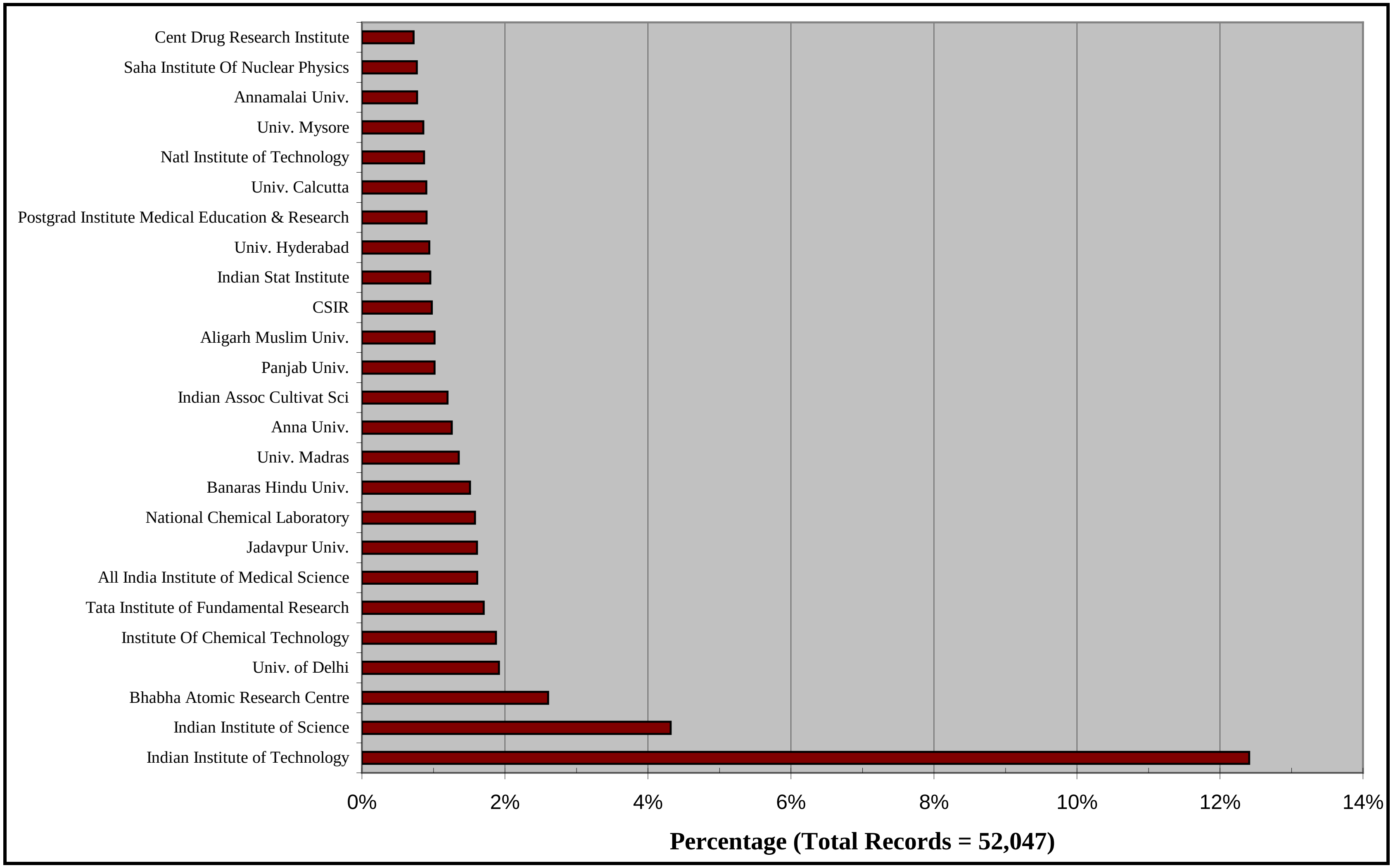

Figure 18. Top 25 SCI/SSCI Author Affiliations for (2005 - 2006)

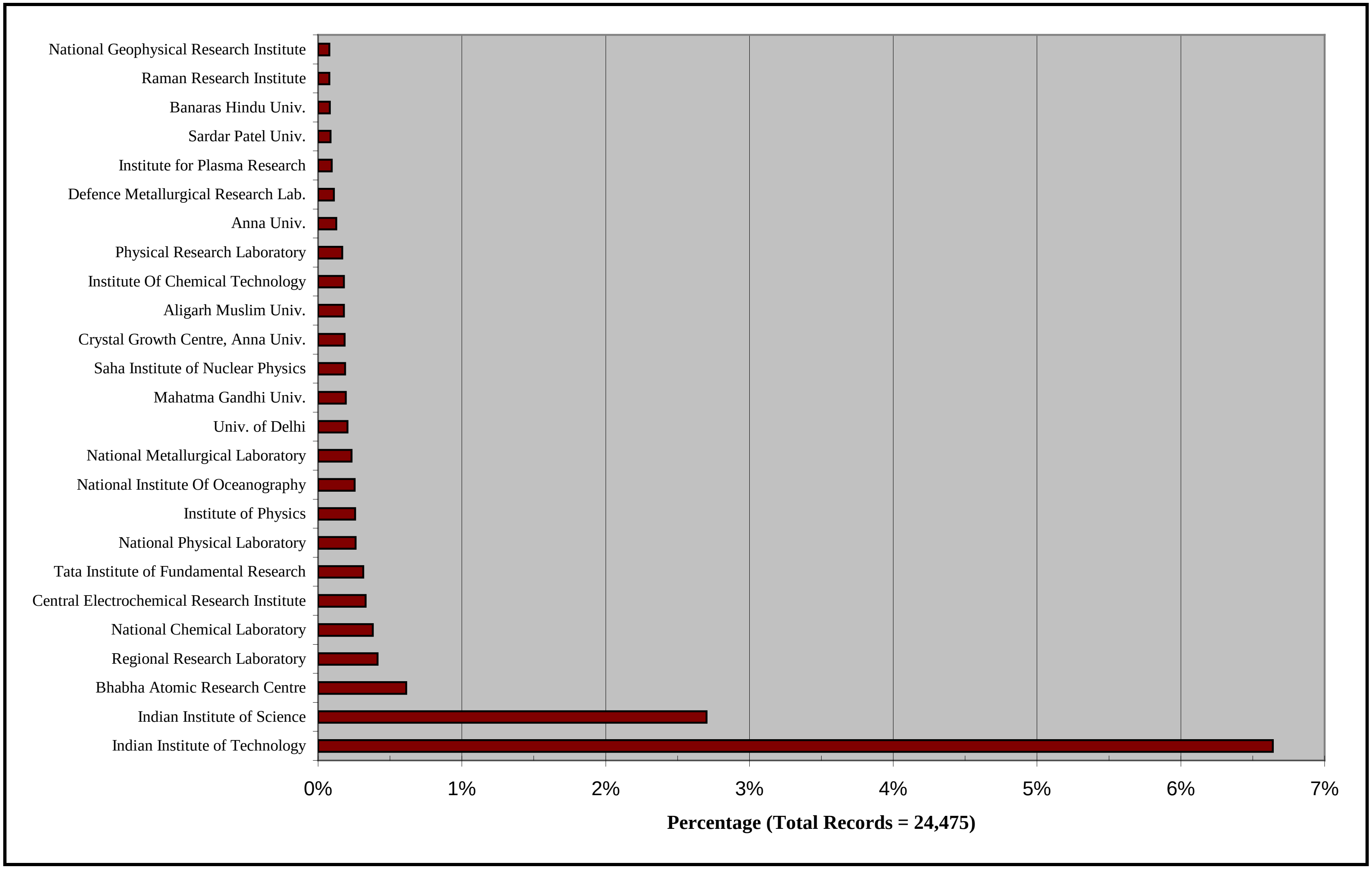

Figure 19. Top 25 EC Author Affiliations for (2005 - 2006)

Again, since several affiliations have numerous facilities located throughout India, the INSPEC data for these entities were grouped or "rolled-up" to allow comparison with SCI/SCCI and EC data for the same period. Figure 20 provides an updated list of the Top 25 INSPEC Author Affiliations for the period (2005-2006). As shown, several of the higher ranked Affiliations are associated with the same leading Institutes, Laboratories and Universities listed for both the SCI/SSCI and EC databases. Primary INSPEC record topics comprise a broad spectrum including physics, electrical/electronic engineering, computing, control engineering, information technology, production, manufacturing and mechanical engineering, materials science, oceanography, nuclear engineering, geophysics, biomedical engineering and biophysics. As such, some of the more notable Affiliations that reflect an increase compared to SCI/SSCI and EC database records include the Raman Research Institute, National Geophysical Research Institute, and Indian Institute of Astrophysics. Note that the bibliometric Author Affiliation data displayed in Figure 20 was produced using gross INSPEC record statistics. The percentage of records published within the Top 25 Affiliations ranged from approximately 0.1 % (Defense Metallurgical Research Lab) – 5.5 % (Indian Institute of Technology), relative to the total number of extracted records (18,988).

Due to the similar coverage of topics for EC and INSPEC databases, Figure 21 provides a combined list of the Author Affiliations for the period (2005-2006). Due to the large number of Affiliation names retrieved, a 0.1 % cutoff, relative to the total number of records retrieved from each database for the two combined years, was used to identify and list the most prominent 34 Institutions, Laboratories and Universities. The 34 Affiliations are listed alphabetically to provide an updated perspective on what specific Affiliation is publishing in either or both databases. As shown, several of the higher ranked or prolific Affiliations include the Indian Institute of Technology, Indian Institute of Science, Tata Institute of Fundamental Research, and the Bhabha Atomic Research Center. Again, note that the bibliometric data displayed in Figure 21 was produced using gross "rolled-up" EC and INSPEC record statistics.

In order to provide a framework for direct comparison to the detailed bibliometric data presented below in Section 3.3 (Prolific Institutions), raw EC and INSPEC Author Affiliation (Top 25) data for the time period (2005-2006) is presented in Figures 22 and 23, respectively. Note that the EC and INSPEC raw data is not "rolled-up" and includes details on the exact location of Top 25 Author Affiliations throughout India.

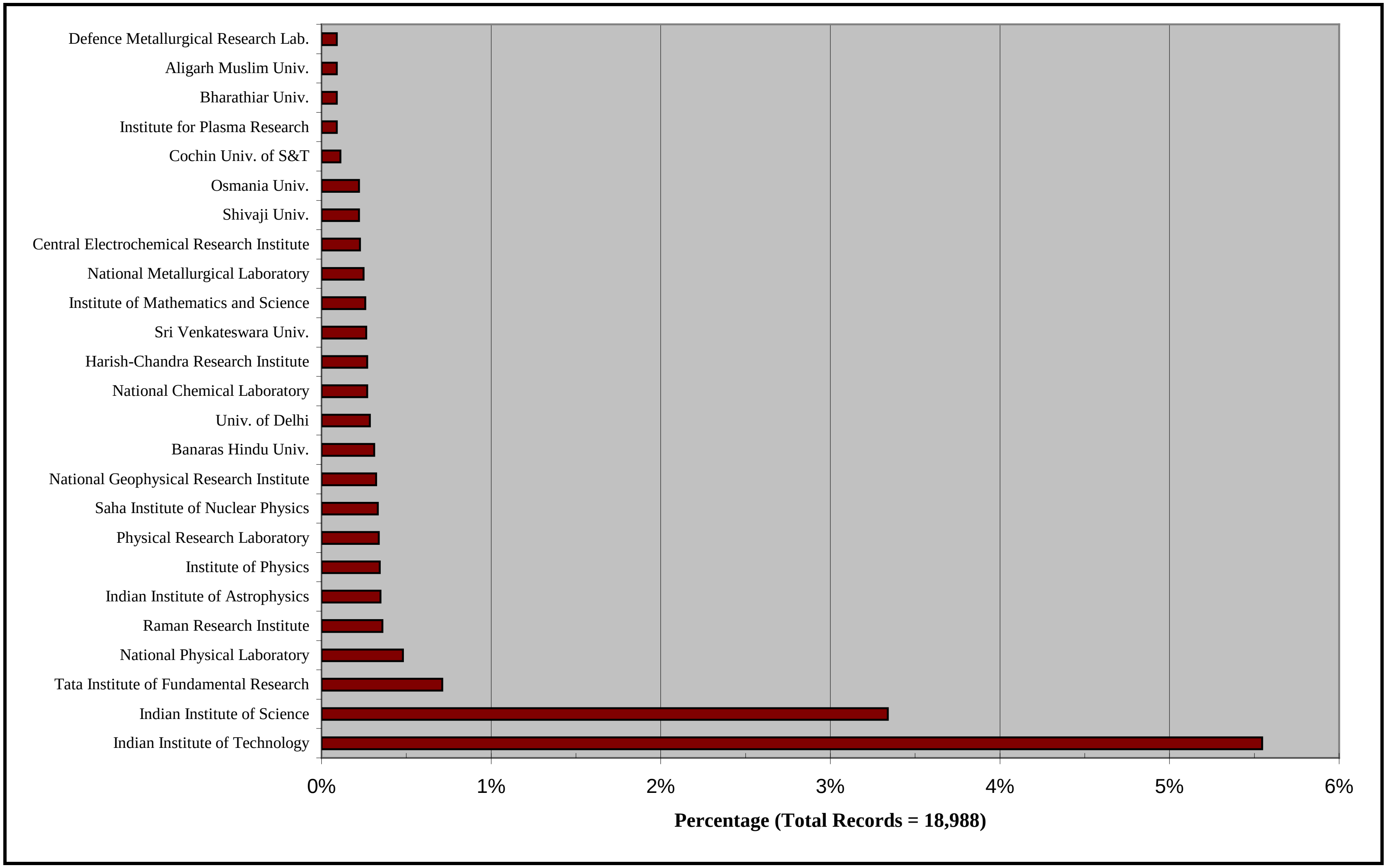

Figure 20. Top 25 INSPEC Author Affiliations for (2005 - 2006)

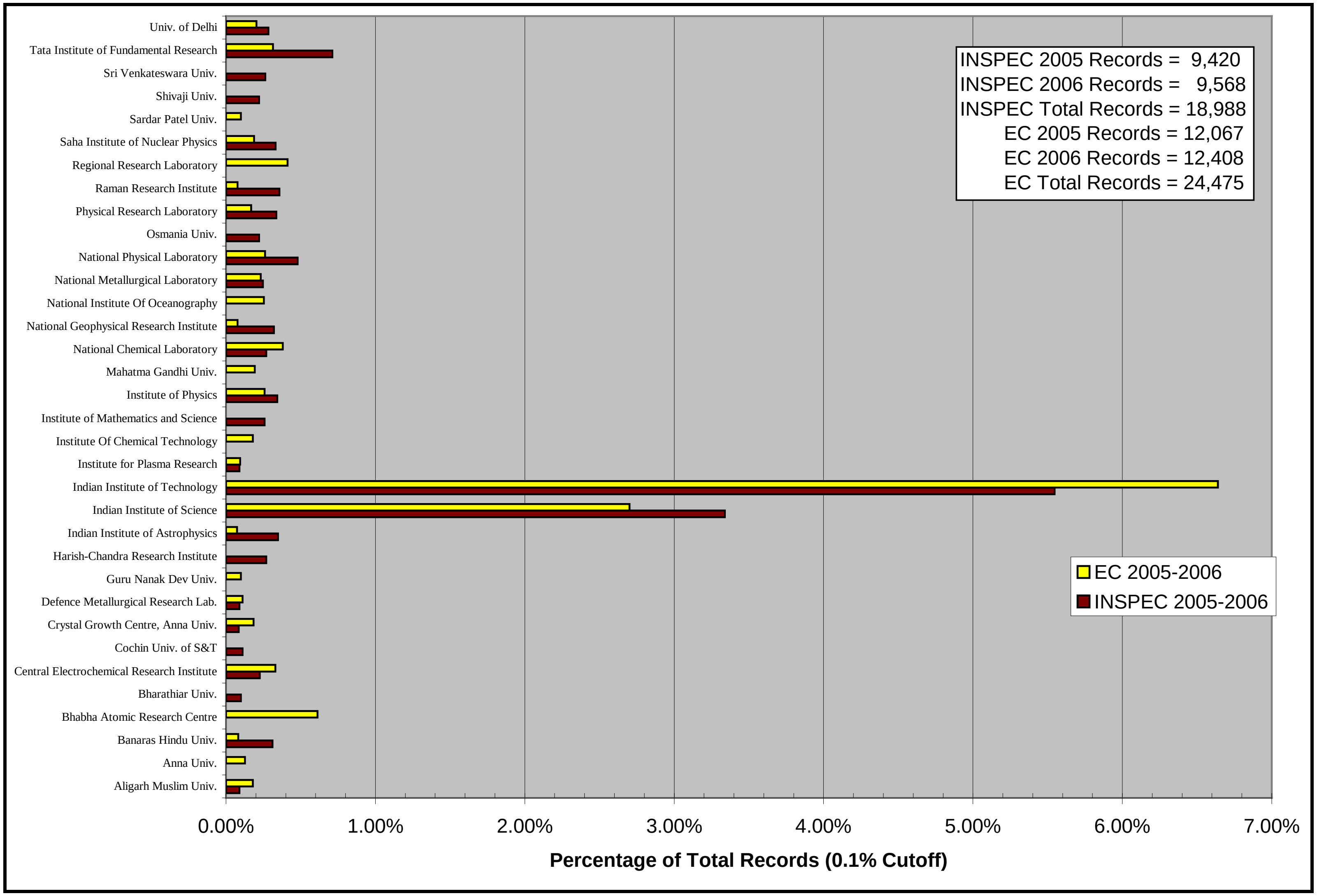

Figure 21. Combined EC and INSPEC Author Affiliations for (2005 - 2006)

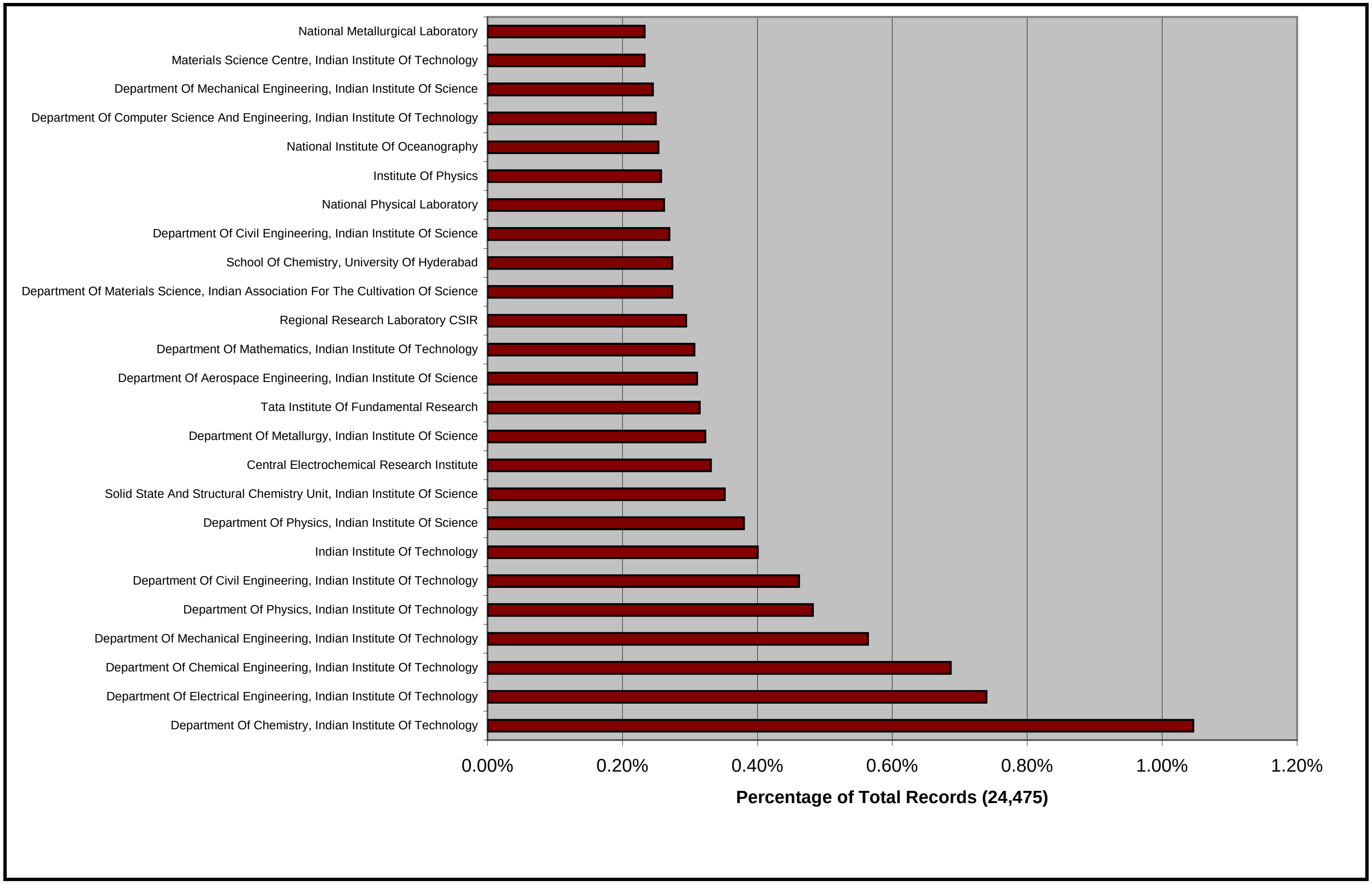

Figure 22. Raw EC Author Affiliations for (2005 - 2006)

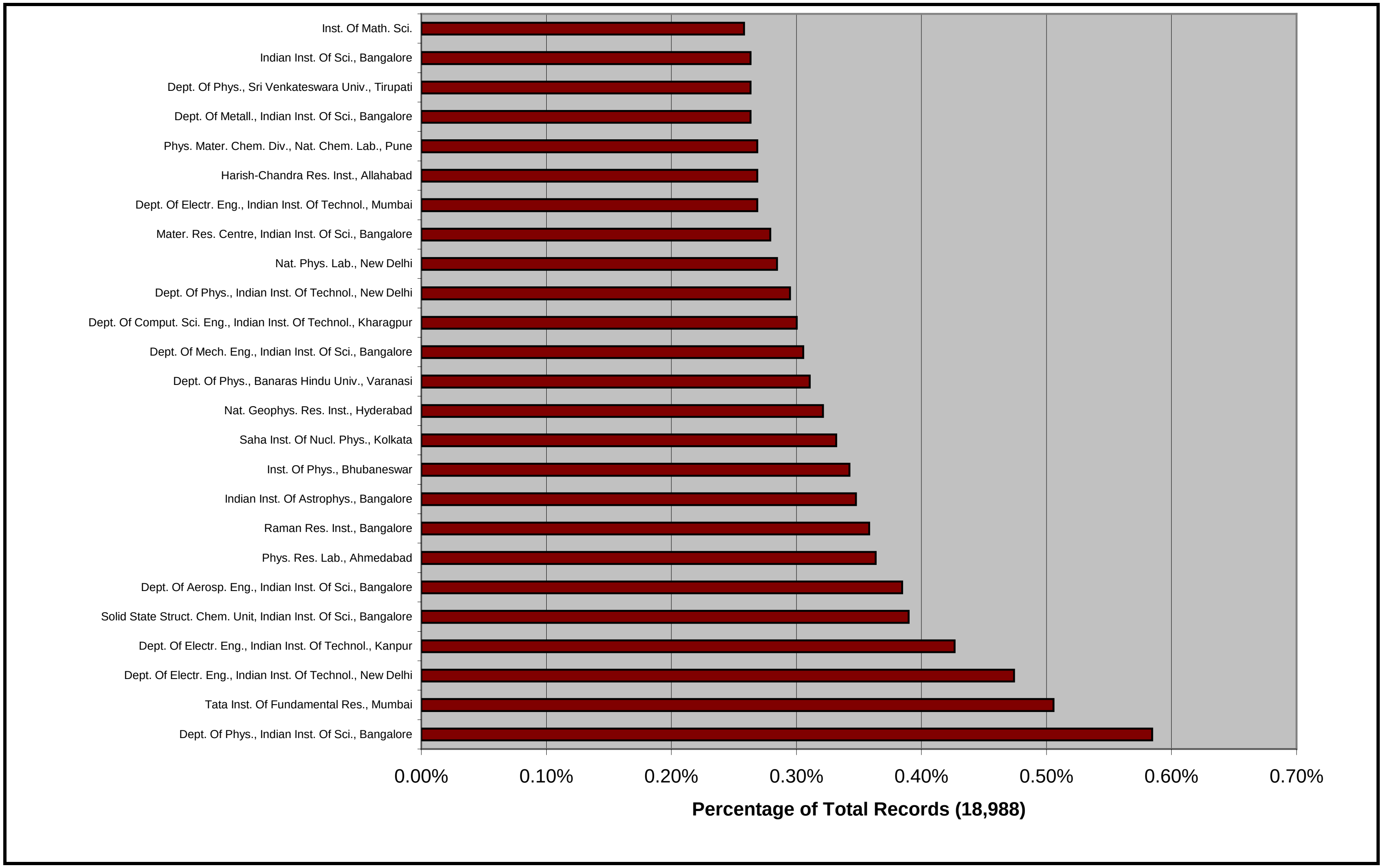

Figure 23. Raw INSPEC Author Affiliations for (2005 - 2006)

3.1.1.3 Publication Trends - Country Collaboration

The following analysis provides publication trends identifying the predominant countries that collaborate on India research. The degree or extent of collaboration for an individual country is based on the total number of research articles containing both India and that specific country address (co-authorship). Figures 24 through 28 show the SCI/SSCI Country Collaborations with India for the period (1980-2005), in intervals. Figure 24 indicates that the predominant Top 10 collaborators for (1980-1985) included the USA, England, Federal Republic of Germany and Canada. The percentage of records published for the Top 10 collaborators ranged from approximately 0.12 % (Netherlands) – 2.4% (USA), relative to the total number of extracted records (64, 600) for this period.

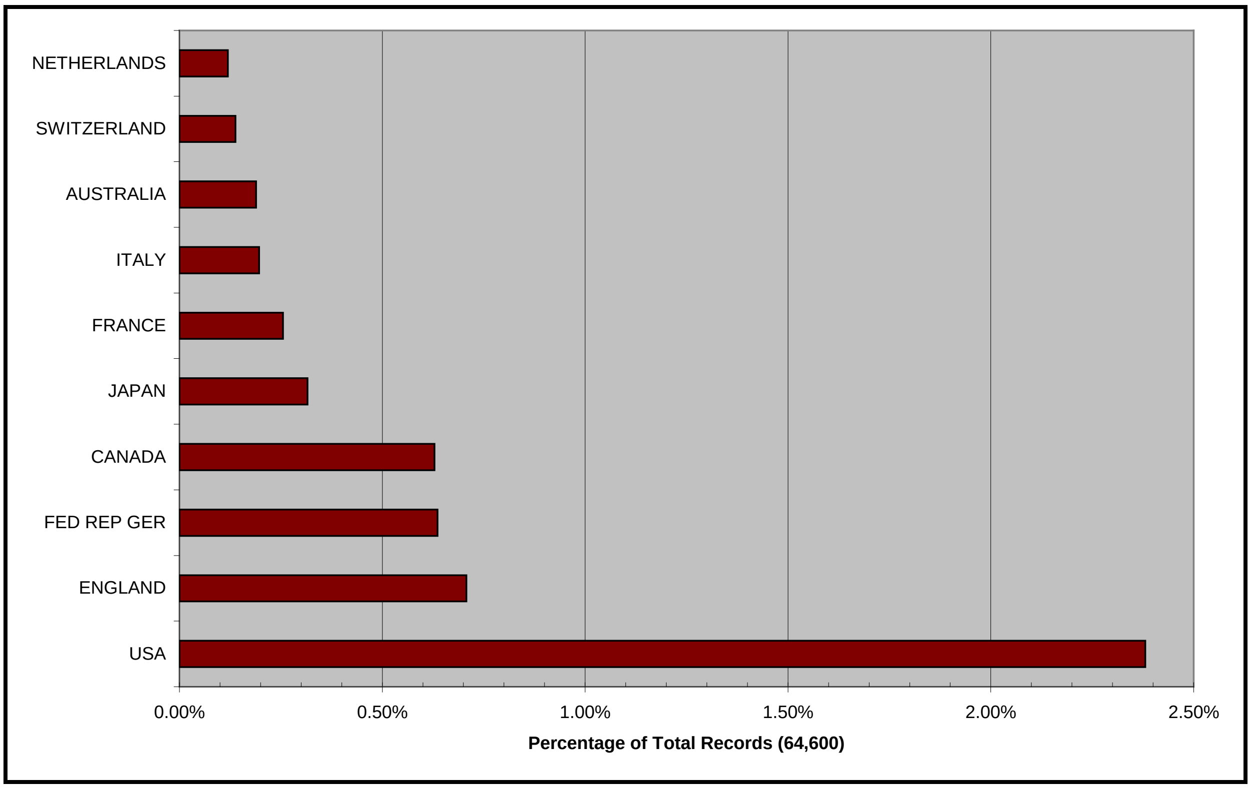

Figure 24. SCI/SSCI Country Collaboration for (1980 - 1985)

Figure 25 indicates that the predominant Top 10 collaborators for (1985 - 1990) included the USA, England, Canada, Federal Republic of Germany and Japan. The percentage of records published for the Top 10 collaborators ranged from approximately 0.18 % (USSR) – 3.2 % (USA), relative to the total number of extracted records (67,416) for this period.

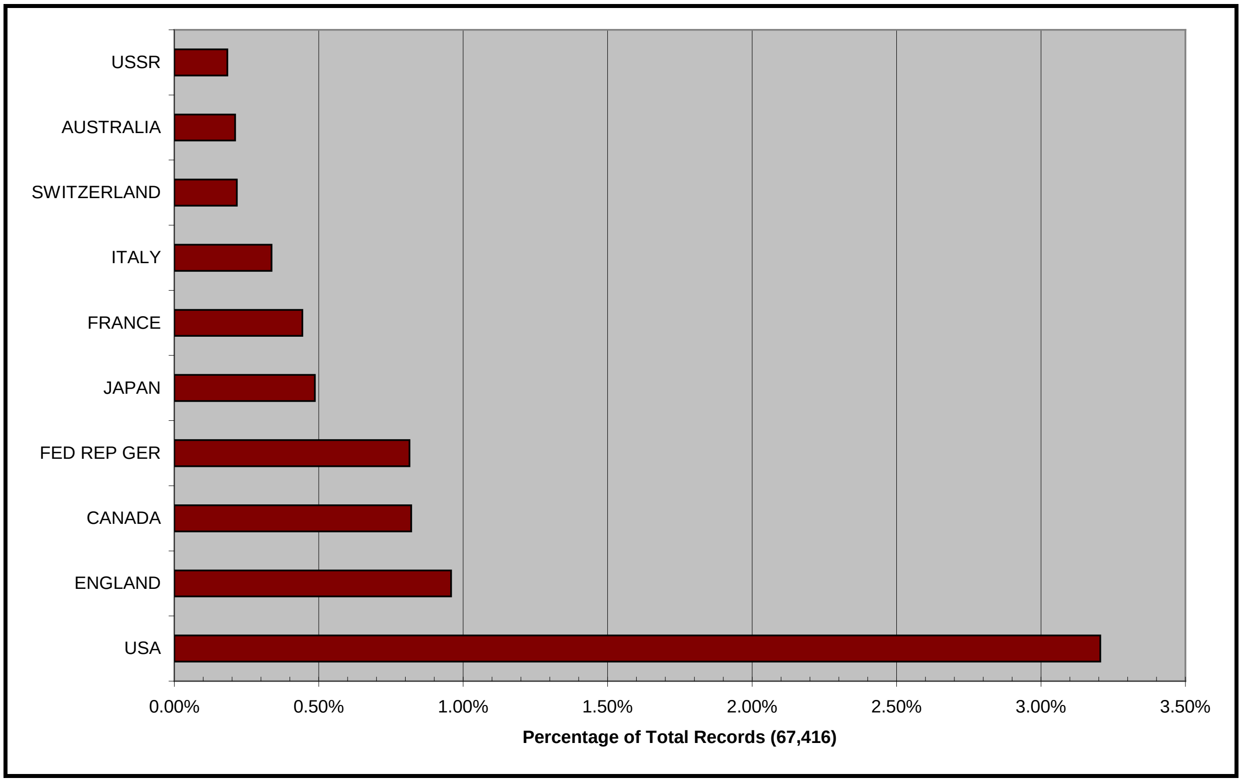

Figure 25. SCI/SSCI Country Collaboration for (1985 - 1990)

Figure 26 indicates that the predominant Top 10 collaborators for (1990 - 1995) included the USA, Germany, England, Canada, and France. The percentage of records published for the Top 10 collaborators ranged from approximately 0.30 % (Netherlands) – 4.3 % (USA), relative to the total number of extracted records (73,202) for this period.

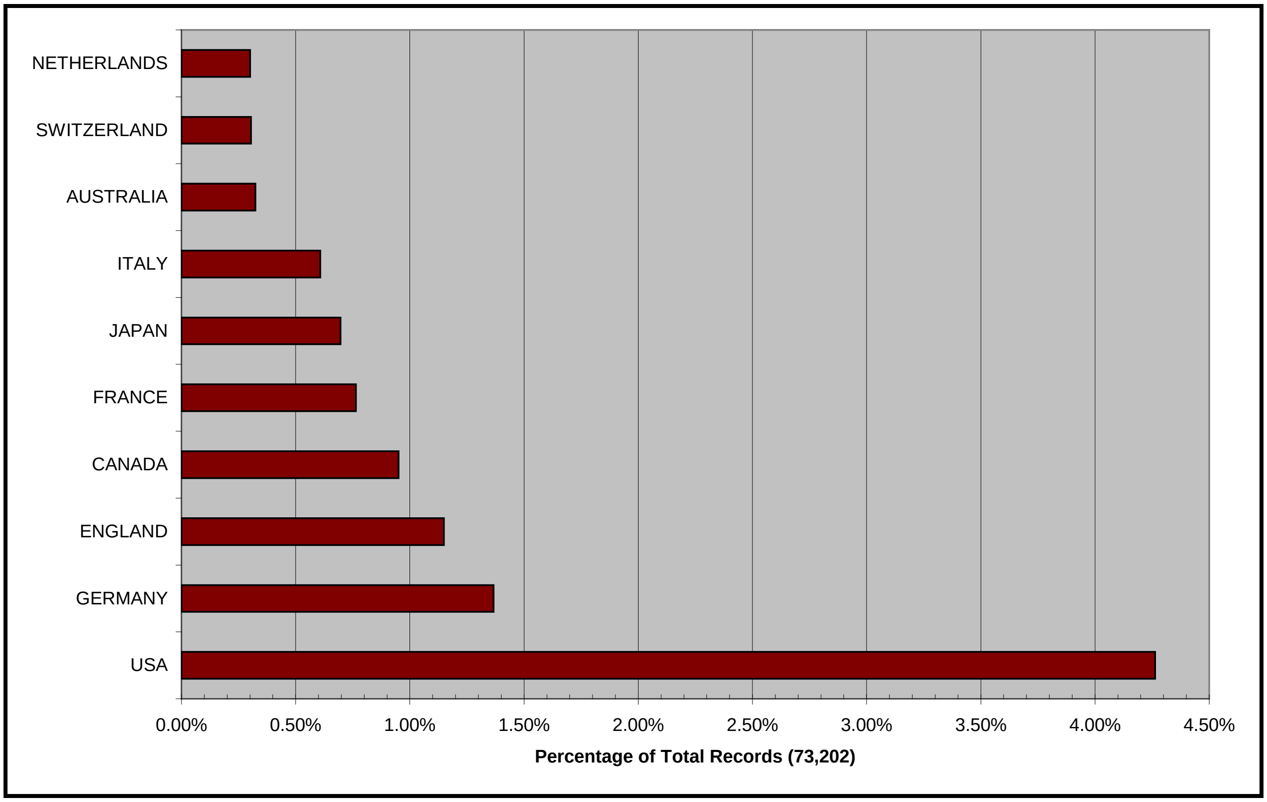

Figure 26. SCI/SSCI Country Collaboration for (1990 - 1995)

Figure 27 indicates that the predominant Top 10 collaborators for (1995 - 2000) included the USA, Germany, England, Japan, and France. The percentage of records published for the Top 10 collaborators ranged from approximately 0.44 % (Netherlands) – 5.6 % (USA), relative to the total number of extracted records (92,909) for this period.

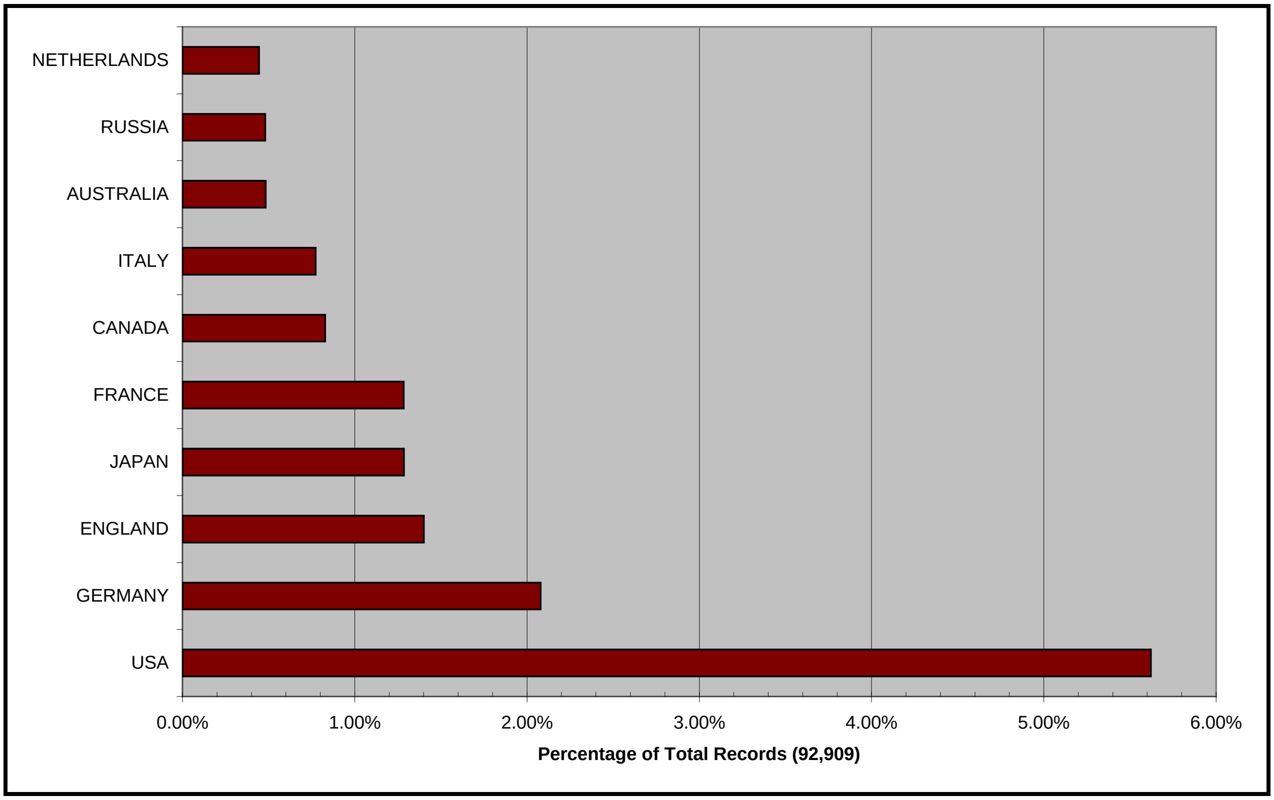

Figure 27. SCI/SSCI Country Collaboration for (1995 - 2000)

Figure 28 indicates that the predominant Top 10 collaborators for (2000 - 2005) included the USA, Germany, Japan, England, and France. The percentage of records published for the Top 10 collaborators ranged from approximately 0.76 % (Australia) – 6.9 % (USA), relative to the total number of extracted records (>100,000) for this period.

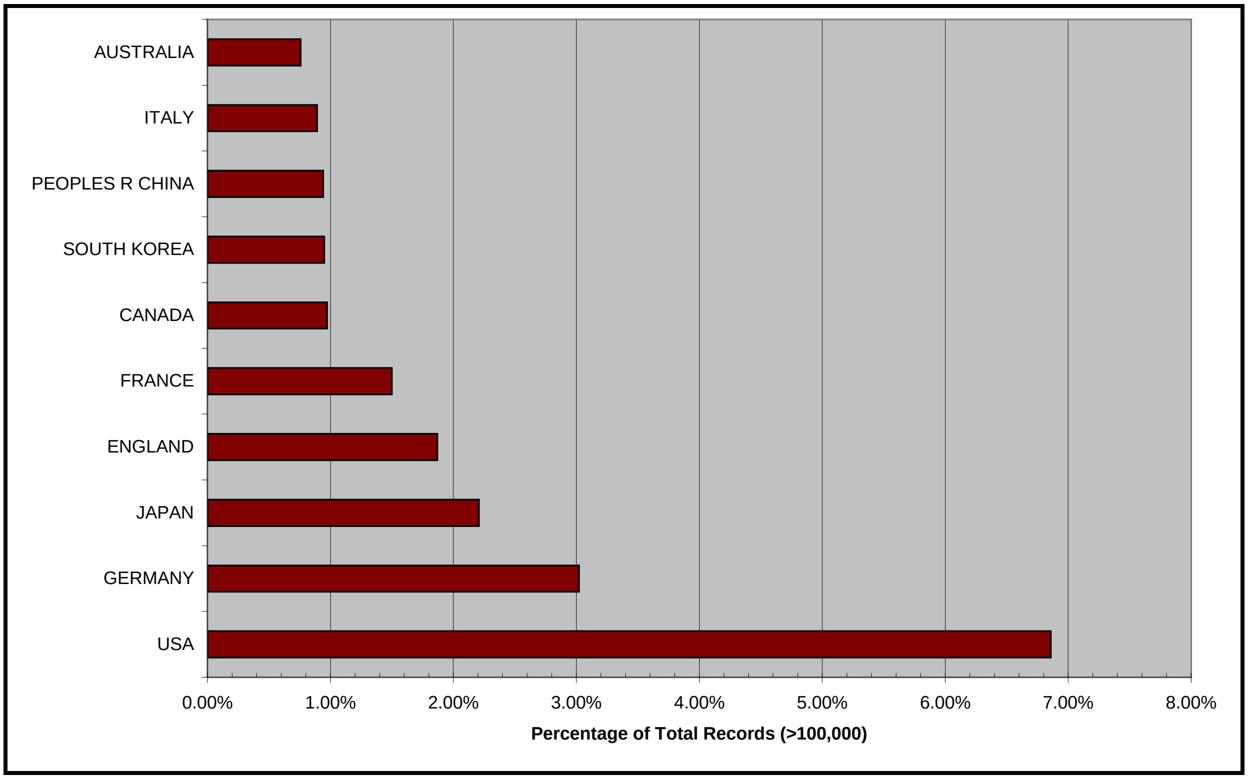

Figure 28. SCI/SSCI Country Collaboration for (2000 - 2005)

Figure 29 indicates that the predominant Top 10 collaborators for (2005 - 2006) remained the USA, Germany, Japan, England, and France. The percentage of records published for the Top 10 collaborators ranged from approximately 0.85 % (Australia) – 6.9 % (USA), relative to the total number of extracted records (52,047) for this period.

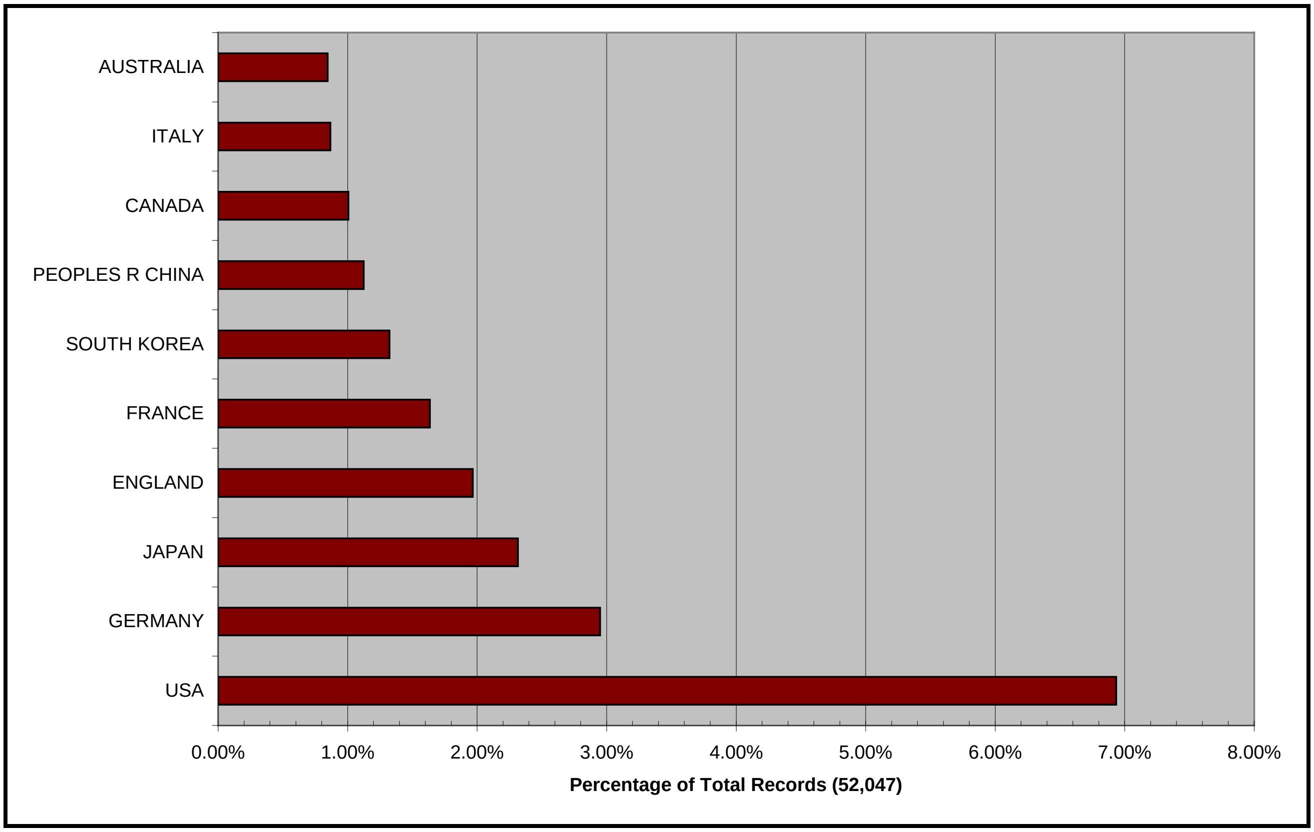

Figure 29. SCI/SSCI Country Collaboration for (2005 - 2006)

Figure 30 shows the 13 predominant collaborators (from all Top 10 groups) for the period (1980-2005). The chart illustrates that the USA has remained as the most dominant collaborator for the entire period. In addition, Asian countries including Japan, Peoples Republic of China, and South Korea have recently significantly increased their collaboration (refer to 00-05 chart legend). The summation of records published for all collaborators for the (1980 – 2005) time period ranged from approximately 1,315 (USSR/Russia) – 18,900 (USA), relative to the total number of published records (53,697). Many of the countries listed in Figure 30 are far smaller than India, yet their current research outputs now are quite similar in magnitude, and their growths have been dramatic.

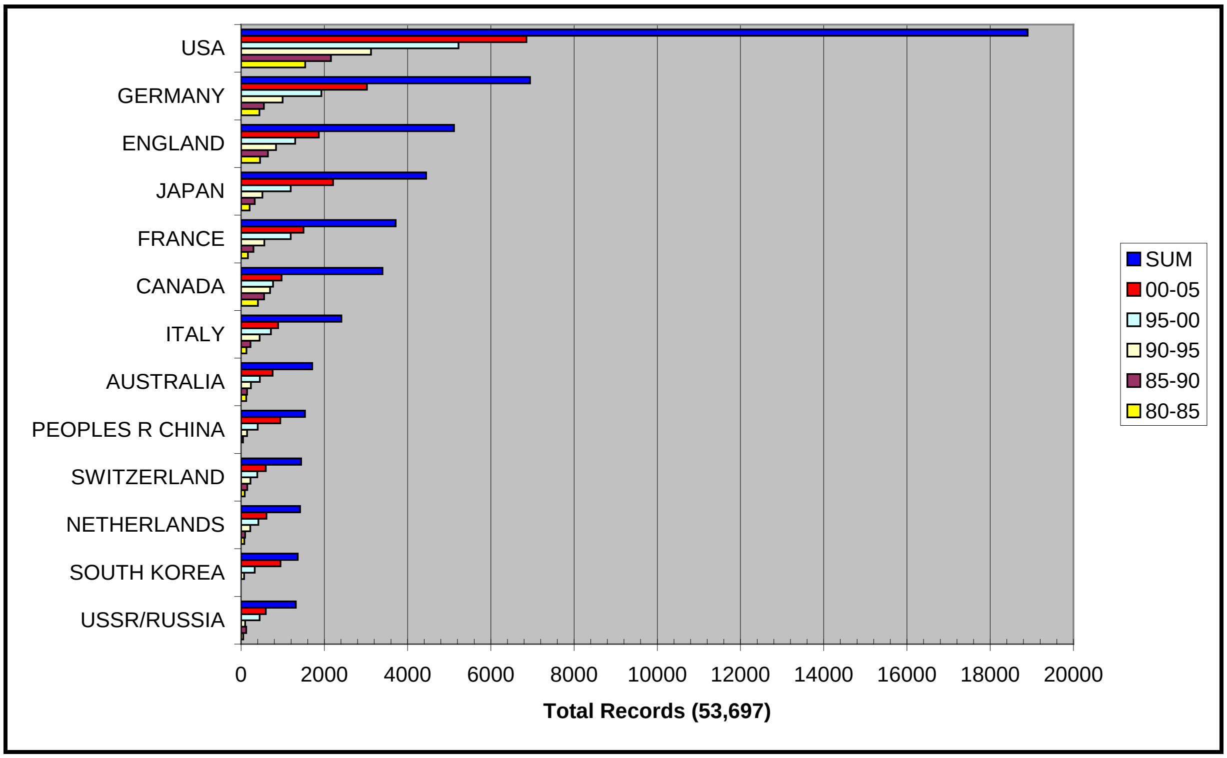

Figure 30. Predominant (Top 10) SCI/SSCI Country Collaboration for (1980 - 2005)

At this point, some strong caveats are in order. Many articles in the open literature imply that a country's research output growth can be represented by the growth in number of SCI/ SSCI, EC and INSPEC articles. However, at a minimum, the growth in articles is a function of

- Increased research sponsorship
- Increased productivity in a country
- Increase in the number of journals accessed by the SCI/ SSCI, EC and INSPEC databases.

The next bibliometrics section (Section 3.2 Journals) contains lists of the top journals in which India authors publish including Journal Impact Factors (measures of a journal's ability to attract citations). To understand better the breakdown among increased research sponsorship, increased productivity and increased numbers of journals accessed, would require modeling the dynamics of publishing in detail. That was beyond the scope of this study. However, a very gross analysis was performed to estimate growth of articles in high Impact Factor (IF) journals for India and select Asian countries. Previous text mining studies of explicit or single technologies over recent years have shown dramatic growth in research output production specifically by South Korea and the Peoples Republic of China, including both bilateral and multilateral collaboration with India. The results of this gross analysis are provided in the following groups of figures in order to provide a better perspective of this collaboration and relative growth in published articles.

Figures 31 through 33 provide a comparison of SCI/SSCI records with both India AND South Korea listed in the Address query field for the (2005 – 2006) time period. Figure 31 shows the percentage of records, relative to the total number of records (689), attributed to all primary Countries, indicating that the USA, Peoples Republic of China, Russia, Germany, Japan and Taiwan as possible primary collaborators with India and South Korea. Figure 31 also shows the Author Affiliations data, indicating that the primary collaborating Institutions, Laboratories and Universities within these countries.

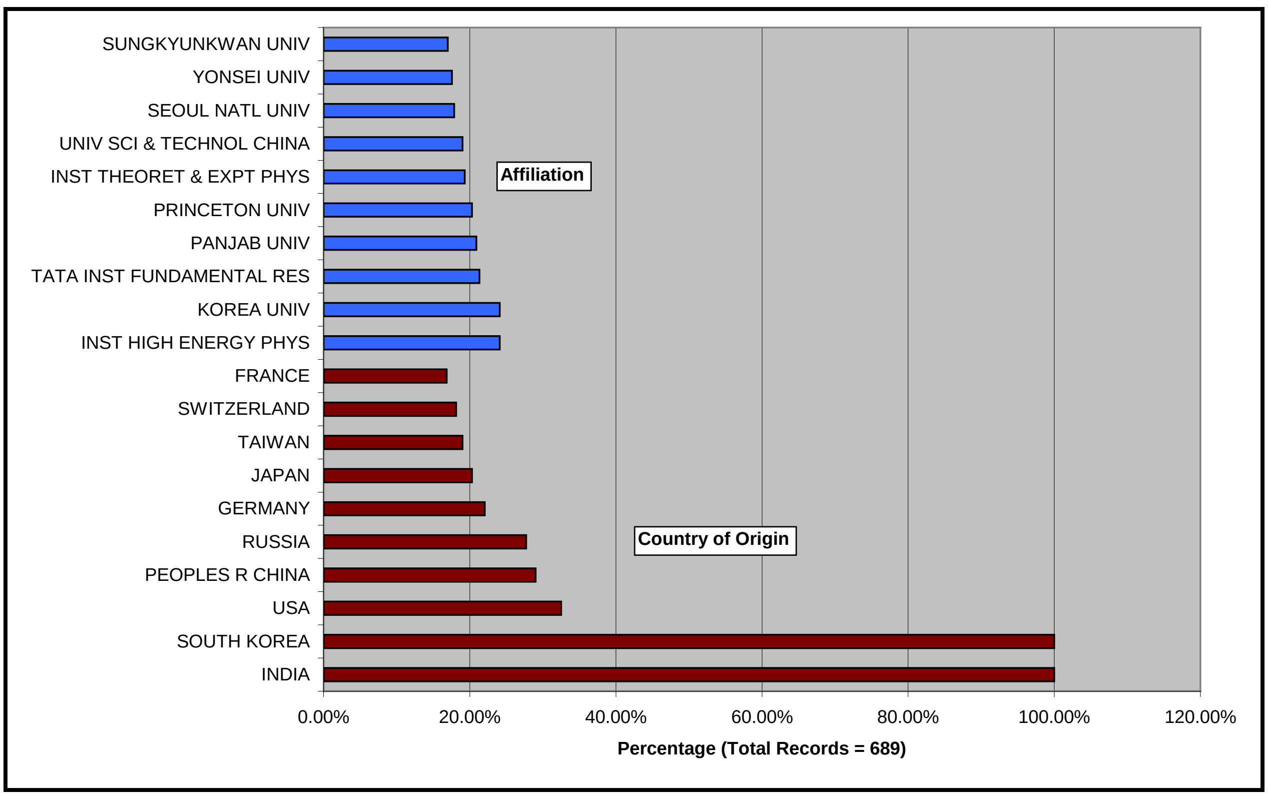

Figure 31. SCI/SSCI India/South Korea Author Affiliations and Country Collaboration

Figure 32 shows the (2005–2006) SCI/SSCI Subject Category data, indicating Physics, Material Sciences, Astronomy, and Chemistry as primary categories. Figure 32 also shows Source data, indicating that the primary collaborating Affiliations are publishing in several major Journals within these technical disciplines including Physical Review Letters, Physics Letters B, Physical Review D, and Materials Science and Engineering B-Solid State Materials for Advanced Technology.

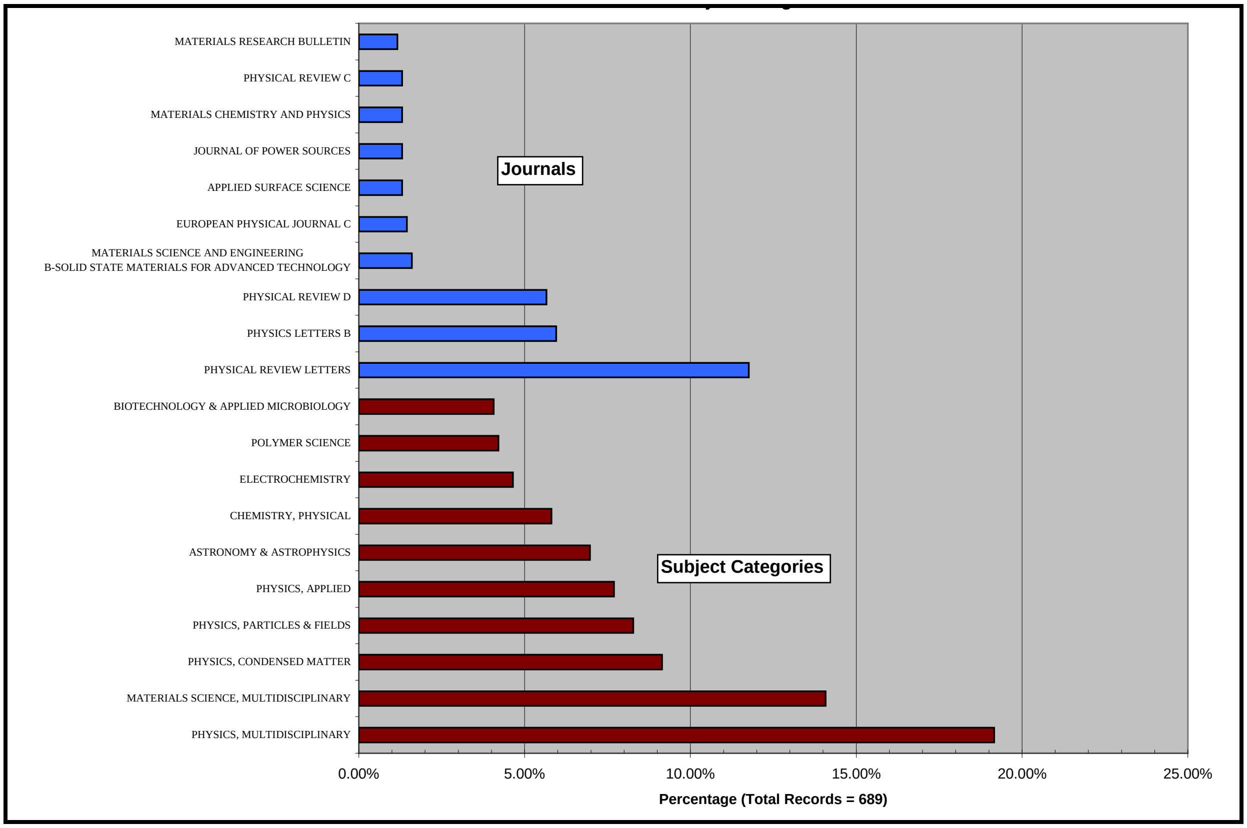

Figure 32. SCI/SSCI India/South Korea Subject Categories and Prolific Journals

Figure 33 shows the (2005–2006) SCI/SSCI Subject Category data as a percentage of the total combined records (197) for the Top 2 Indian Author Affiliations (TATA Institute of Fundamental Research and PANJAB University), indicating Physics, Astronomy, and Computer Sciences as primary categories.

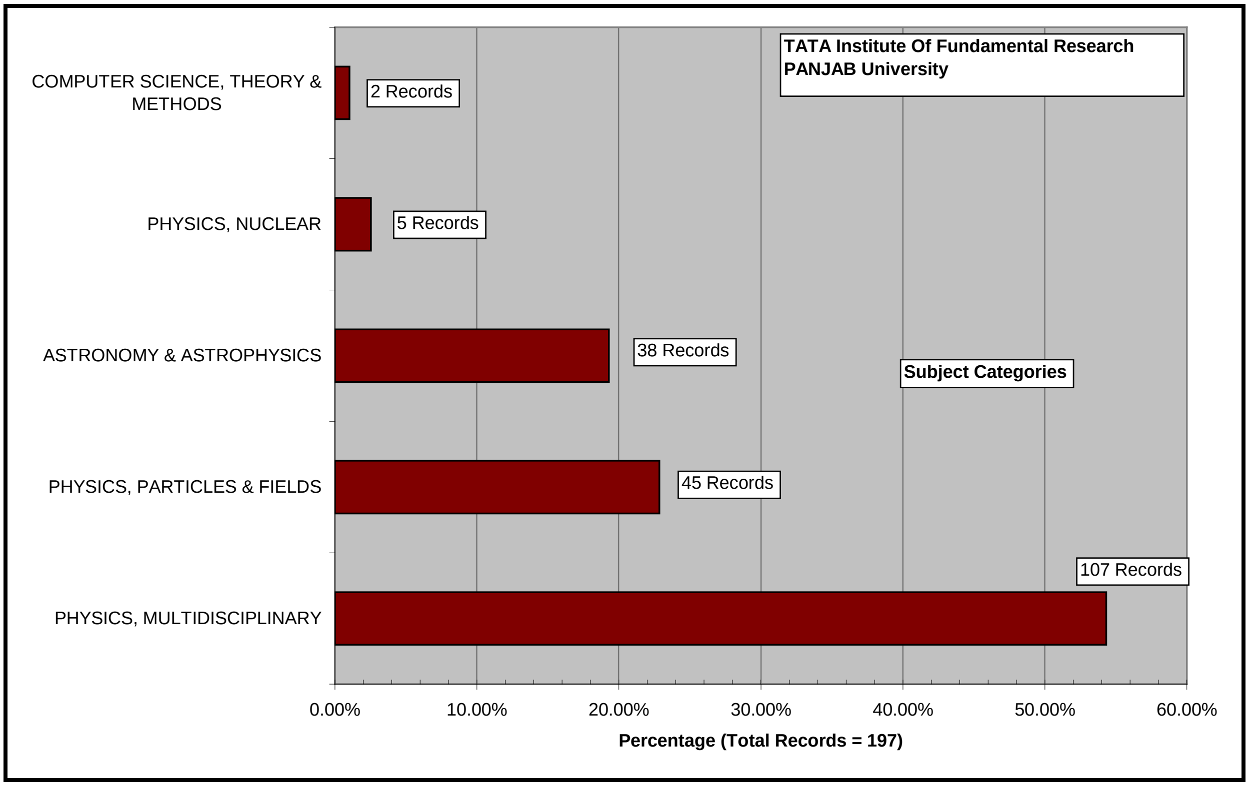

Figure 33. SCI/SSCI India/South Korea Subject Categories
(Top 2 Collaborating Institutions)

Since, the EC and INSPEC databases allow only one country address in search queries (single-valued field), Boolean "AND" queries using multiple countries are not permissible. Therefore, the retrieved research articles from the EC and INSPEC databases do not reflect direct collaboration between countries (based on co-authorship) as they also contain only one country address. In order to provide some perspective on possible collaboration between India and South Korea a brief analysis was performed using a query with India listed in the Country address field AND South Korea listed in all fields (other than address field) for the (2005-2006) time period.

Figure 34 shows a synopsis of the EC and INSPEC author affiliation, controlled vocabulary and classification data as a percentage of the total combined records (200). Note that that the Vocabulary and Classification data reflect technical disciplines associated with electronic equipment, computer, radar, radio and television applications.

As mentioned in Section 1 (Introduction), in addition to South Korea, previous text mining studies over recent years have shown dramatic growth in research output production by the Peoples Republic of China, including both bilateral and multilateral collaboration with India. In order to gain a better perspective of this collaboration, Figures 35 through 38 provide a comparison of SCI/SSCI records with both India AND Peoples Republic of China listed in the Address query field for the (2005-2006) time period.

Figure 35 shows the percentage of records, relative to the total number of records (584), attributed to all primary Countries, indicating that the USA, Russia, South Korea, and Germany as possible primary collaborators with India and the Peoples Republic of China. Figure 35 also shows the Author Affiliations data, indicating that the primary collaborating Institutions, Laboratories and Universities within these countries.

Figure 36 shows the (2005–2006) SCI/SSCI Subject Category data, indicating Physics, Material Sciences, Astronomy, and Chemistry as primary categories. Figure 36 also shows Source data, indicating that the primary collaborating Affiliations are publishing in several major Journals within these technical disciplines including Physical Review Letters, Physics Letters B, Physical Review D, Physical Review C and the European Physical Journal C.

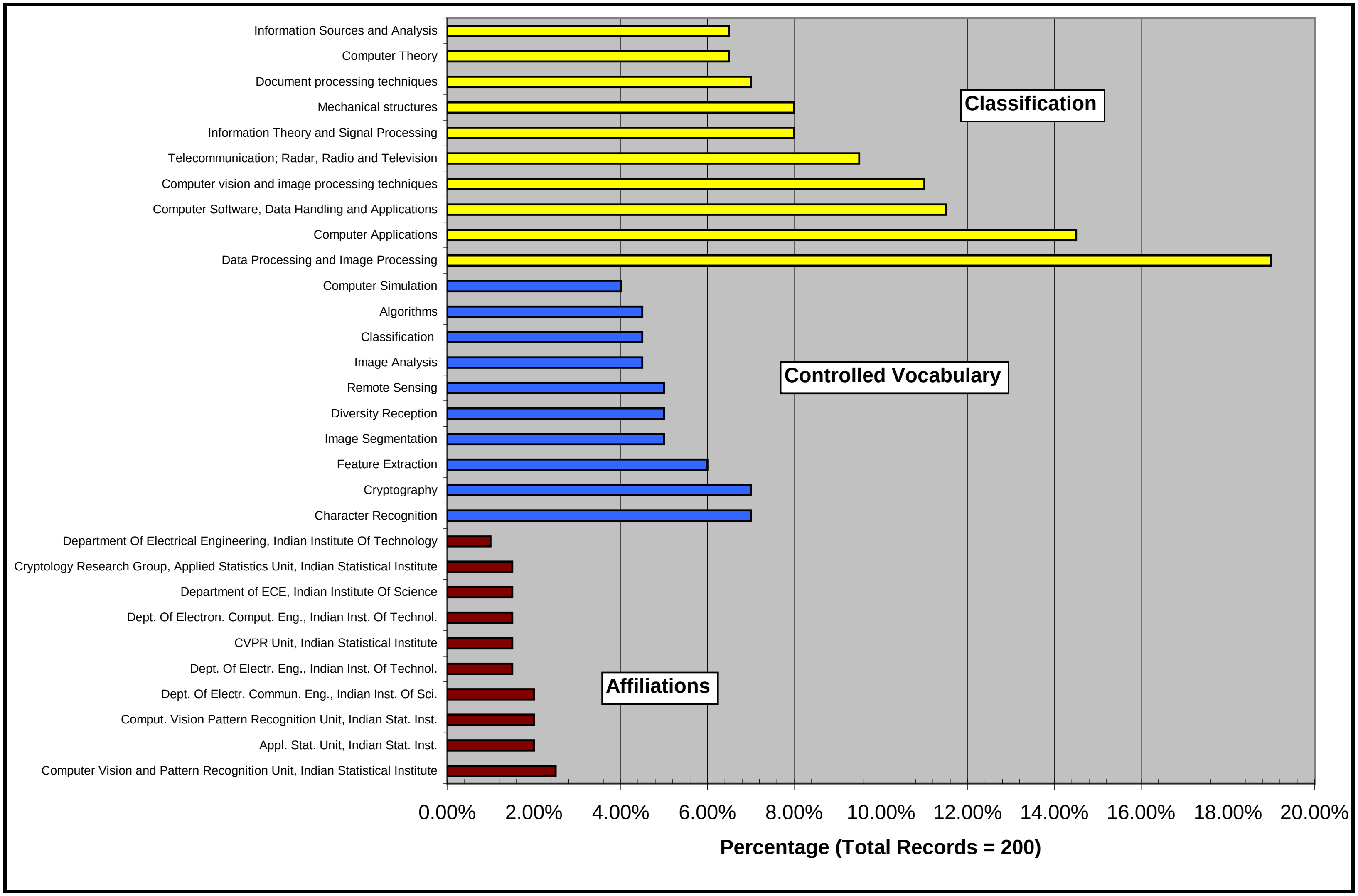

Figure 34. EC and INSPEC India/South Korea Author Affiliations, Controlled Vocabulary and Classifications

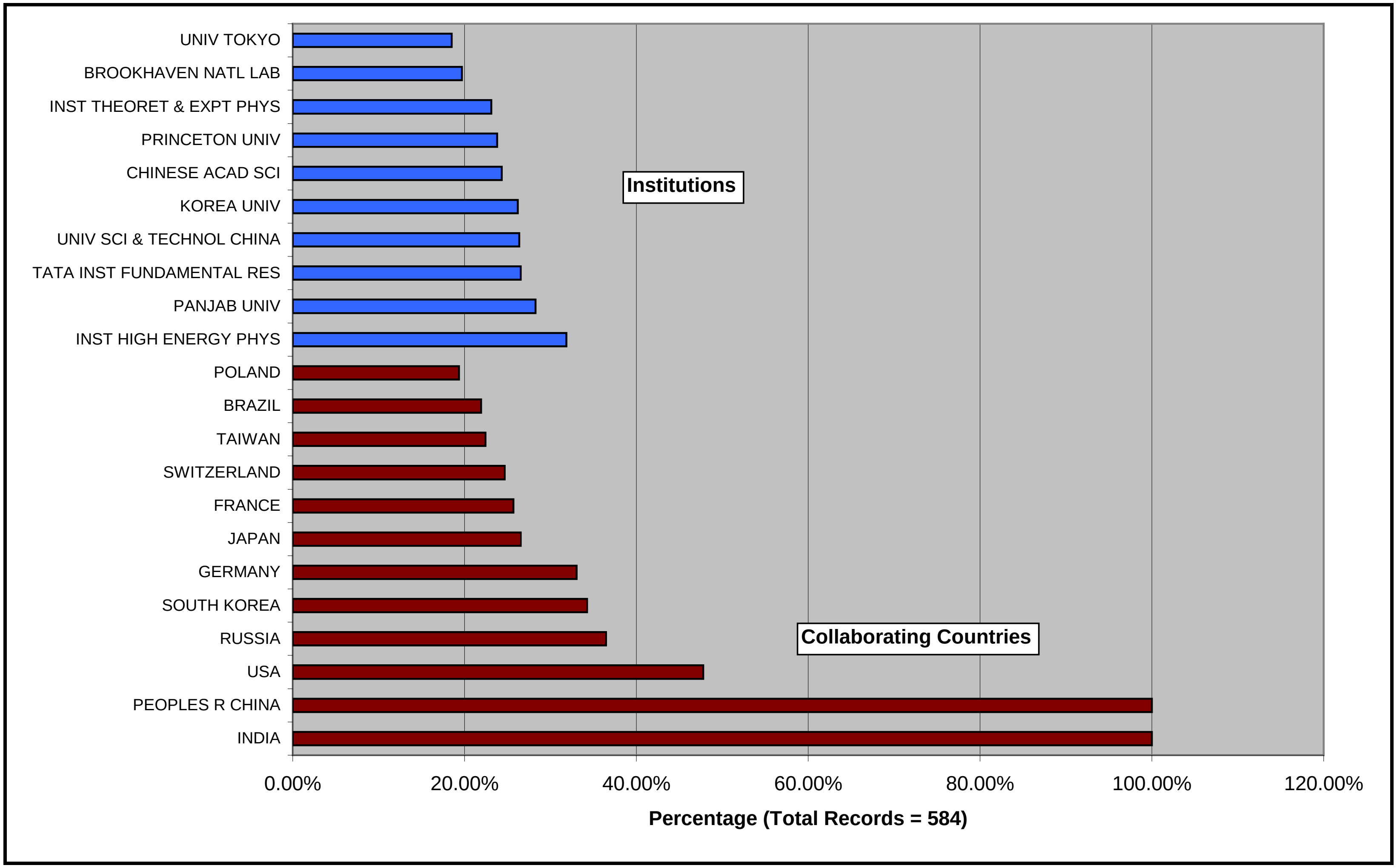

Figure 35. SCI/SSCI India/China Collaborating Author Affiliations and Countries

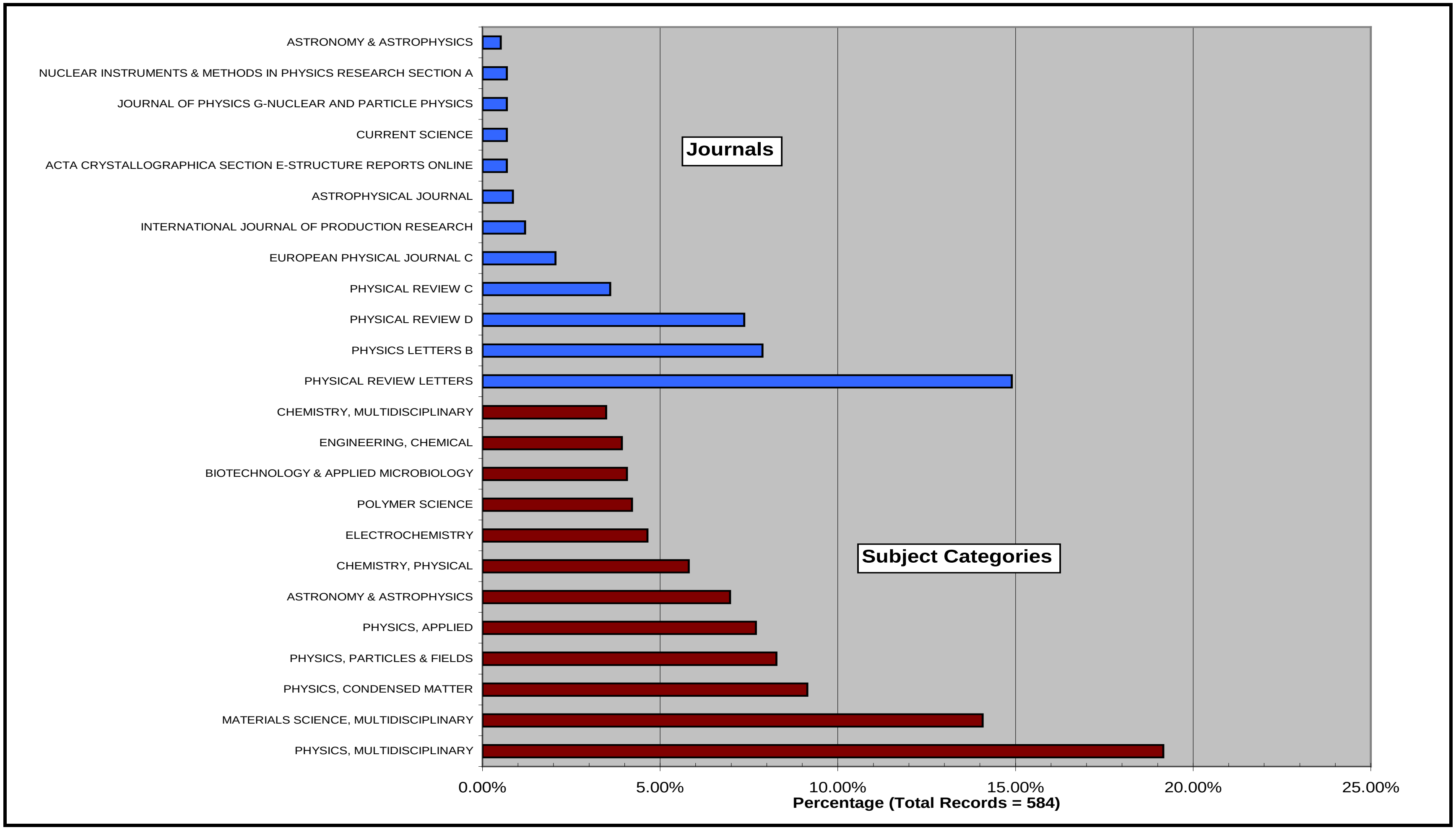

Figure 36. SCI/SSCI India/China Subject Categories and Source Journals

Figure 37 shows the (2005-2006) SCI/SSCI Subject Category data as a percentage of the total combined records (186) for the Top 2 Indian Author Affiliations (TATA Institute of Fundamental Research and PANJAB University), indicating Physics, Astronomy, Instruments and Instrumentation, Mathematics and Spectroscopy as primary categories.

Again, since, the EC and INSPEC databases allow only one country address in search queries (single-valued field), Boolean "AND" queries using multiple countries are not permissible. Therefore, the retrieved research articles from the EC and INSPEC databases do not reflect direct collaboration between countries (based on co-authorship) as they also contain only one country address. In order to gain some perspective on possible collaboration between India and Peoples Republic of China, a brief analysis was performed using a query with India listed in the Country address field AND China listed in all fields (other than address field) for the (2005-2006) period.

Figure 38 shows a synopsis of the EC and INSPEC author affiliation, controlled vocabulary and classification data as a percentage of the total combined records (712). Note that that the Vocabulary and Classification data reflect technical disciplines associated with computer and electronic equipment applications; applied mathematics, control systems and theory, optical, image and video signal processing, and artificial intelligence.

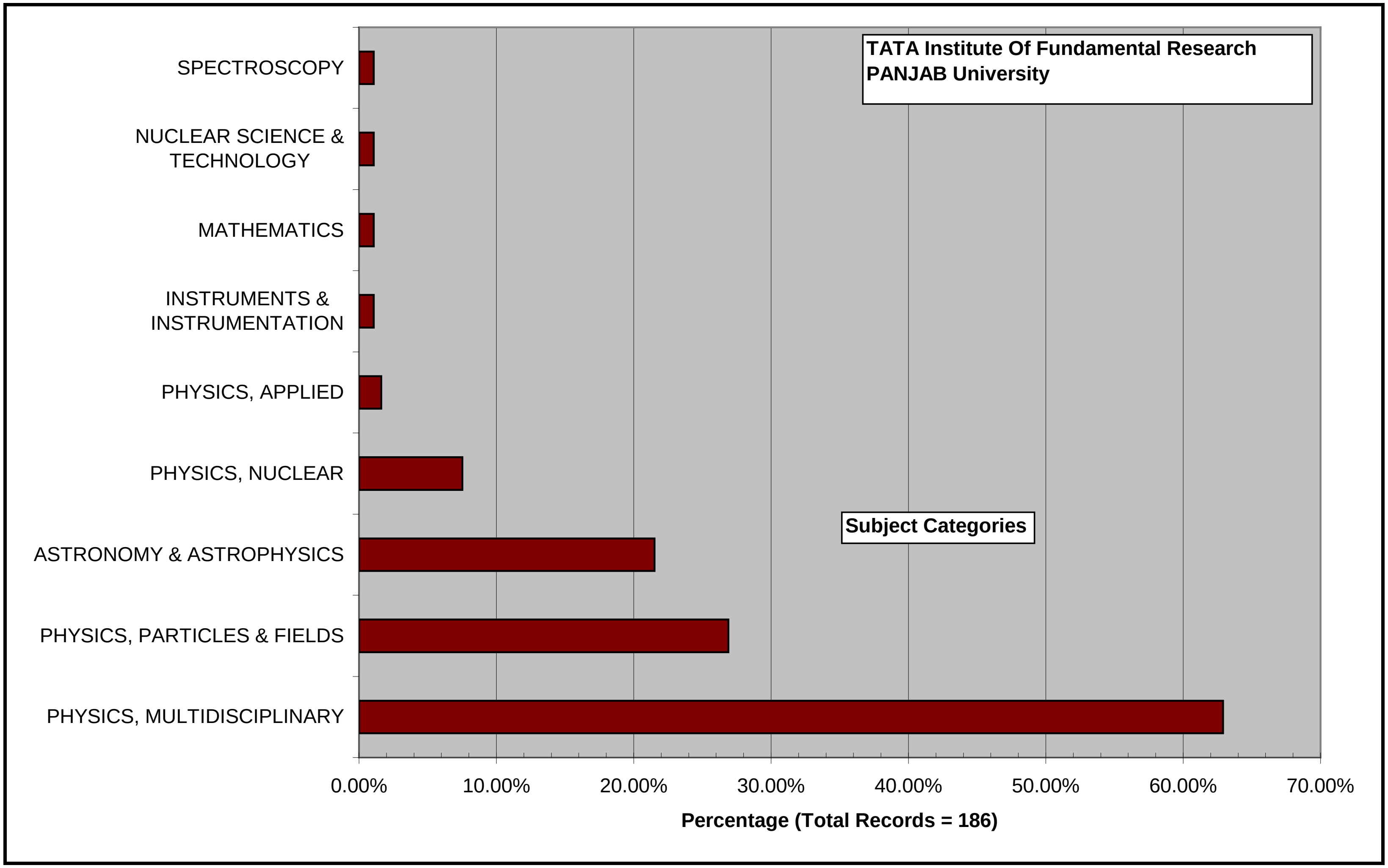

Figure 37. SCI/SSCI India/China Subject Categories (Top 2 Collaborating Institutions)

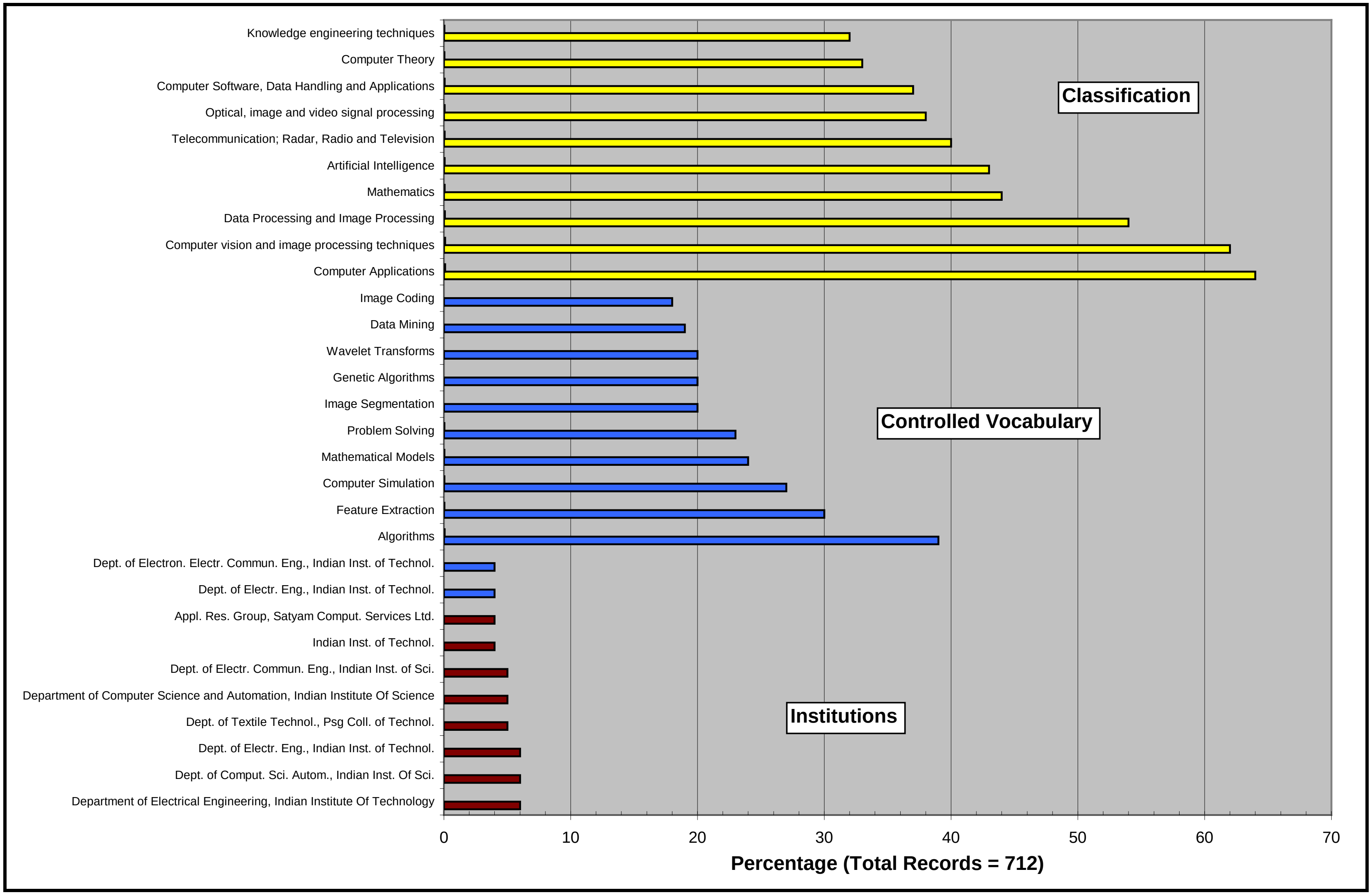

Figure 38. EC and INSPEC India/China Author Affiliations,
Controlled Vocabulary and Classifications

In addition to the gross bibliometric analysis performed for China and presented above, a very brief analysis was performed in mid-March 2006 (Ref. 1) to estimate the growth of India and China articles in high Impact Factor journals. This prior analysis indicated the journals cited most frequently by Indian and Chinese authors have substantial overlap, and are well-recognized high quality journals. Three of the five most highly cited journals (one in each of the following disciplines: chemistry, physics, biology) were selected, and the numbers of papers published with India and China authors were examined as a function of time. Table 5 contains the results.

Prior to the mid-1990s, the numbers of India and China articles in these three journals were relatively low. Therefore, only the data from the mid-1990s to the present are presented. India had noticeably more publications in the three journals prior to about 2000. Since 2000, China has noticeably more publications than India in these journals, and the lead over India is increasing.

TABLE 5. INDIA / PEOPLES REPUBLIC OF CHINA PUBLICATIONS
IN SELECTED JOURNALS

	JACS		P REV LETT		J BIO CHEM	
YEAR	**INDIA**	**CHINA**	**INDIA**	**CHINA**	**INDIA**	**CHINA**
1995	5	2	34	14	9	2
1996	17	5	49	33	13	2
1997	17	11	52	31	17	7
1998	23	12	66	56	10	7
1999	11	13	51	39	23	16
2000	19	35	54	70	17	25
2001	15	49	59	85	42	46
2002	14	45	49	82	31	56
2003	19	89	55	134	60	83
2004	15	99	50	151	54	110
2005	27	142	52	158	44	124
2006	4	22	8	28	2	13

CODE:
JACS=Journal of the American Chemical Society
P REV LETT=Physical Review Letters
J BIO CHEM=Journal of Biological Chemistry

How does the growth in these three highly cited journals compare with the overall research article growth of India and China (shown previously) in this period? From 1995 to 2000, India's overall article growth increased by about a third (16203/ 12602). In Table 5, in all three journals, India's growth over this period is greater than a third, ranging from factors of 1.5 to 4. From 1995 to 2000, China's overall article growth increased by almost a factor of three (29292/ 11402). In Table 5, China's increase over the same period ranged from factors of 5 to 10, outpacing its overall growth, and noticeably greater than India's. From 2000 to 2005, India's overall article growth was about 50% (25367/16203). In Table 5, India's article growth ranged from factors of zero to 2.5, on average matching its overall article growth during this period. China's overall article growth during this period was about a factor of 2.5 ((72310/ 29292), while China's article output growth in ranged from factors of 2.2 to 5, thereby outpacing its total article growth once again. Thus, for an admittedly limited sample of the highest cited discipline journals by China and India, China strongly outpaced India in growth over the time period examined, and outpaced its own overall research article growth as well.

The message to be taken from this analysis is that both India and China are increasing their growth of articles in highly cited journals greater than their overall increase in growth of research articles. India's relative increase is modest, whereas China's increase is strong. For both countries, much of the increase in overall research article growth comes from increasing production of articles in low Impact Factor domestic and international journals. In addition, for both countries, there is increased production in high Impact Factor journals as well. The increase in high Impact Factor journals outpaces the increase in overall research article production, but the high Impact Factor journal production is a relatively small fraction of the overall research article production. As previously stated, overall country research publication outputs can be misleading. Not only are publications in the commercial and military critical technology areas of high importance, but also, as the above brief analysis has shown, publications in journals with high impact factor are also of high importance (Ref. 1).

3.2 Prominent Journals

This section contains lists of the prominent journals in which India authors publish, including Journal Impact Factors (measures of a journal's ability to attract citations). The analysis specifically addresses Journals containing most India-authored research articles and most cited Journals.

3.2.1 Journals Containing Most India-authored Articles

The Top 50 journals containing the most research articles with at least one India author (from the retrieved SCI/SSCI 2005-2006 database) are shown on Table 6. The highest-ranking journals emphasize chemistry, veterinary, agriculture, and physics. For the Top 50 SCI/SSCI journals listed, 18 (highlighted) are domestic Indian journals with relatively low journal Impact Factors. In addition, for the Top 50 SCI/SSCI journals listed, 27 journals have Impact Factor less than unity. The Top 25 journals containing the most research articles with at least one India author (from the retrieved EC 2005-2006 database) are shown on Table 7. The highest-ranking journals emphasize a broad range of themes including computer science, physics, chemistry and materials science. For the Top 25 EC journals listed, three (3) are domestic Indian journals (highlighted) with relatively low journal Impact Factors, as opposed to the majority of journals that have Impact Factor greater than unity. The Top 25 journals containing the most research articles with at least one India author (from the retrieved INSPEC 2005-2006 database) are shown on Table 8. As expected, the highest-ranking journals emphasize a similar broad range of themes to the EC retrieved database journal themes. For the Top 25 INSPEC journals listed, five (5) are domestic Indian journals (highlighted) with relatively low journal Impact Factors, as opposed to the majority of journals that have Impact Factor greater than unity. Many causes can contribute to low journal Impact Factor. These include low quality publications and/or limited journal circulation and/ or overly applied papers and/ or technical field covered (i.e., number of researchers working in technical field and available to cite papers). This present study did not distinguish among these causes for the journals listed below. In the preceding India study, analysis was performed to establish a benchmark for journals containing the most research papers published by authors in India, USA, and China. The medians of the journal Impact Factors were calculated (USA: 4.74; China: 0.59; and India: 0.40 indicating that *USA Impact Factors are an order of magnitude greater than those of China or India*. It was also shown that *collaboration has the effect of dramatically increasing the presence of papers with India authors in the higher Impact Factor journals.* The effect of collaboration on citations will be addressed in the section on collaborative countries. It should be noted that the SCI/SSCI database provides access to Journal Citation Reports that were used to generate the data listed in Table 6. The EC and INSPEC databases do not provide this capability and therefore the data listed in Tables 7 and 8 were generated manually. Only the Top 25 EC and INSPEC Journals were analyzed in this manner.

TABLE 6. TOP 50 SCI/SSCI JOURNALS CONTAINING MOST ARTICLES BY INDIA AUTHORS

SCI / SSCI Journal Bibliometrics (2005 - 2006)							
Rank	JOURNALS	# Records	2005 Total Cites	Impact Factor	Immediacy Index	2005 Articles	Cited Half-Life
1	CURRENT SCIENCE	774	3451	0.728	0.294	537	6.2
2	INDIAN VETERINARY JOURNAL	747	800	0.052	0.009	438	>10.0
3	INDIAN JOURNAL OF ANIMAL SCIENCES	602	1051	0.09	0.016	312	5.7
4	TETRAHEDRON LETTERS	574	69531	2.477	0.532	1956	7.6
5	ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	547	3322	0.581	0.325	2849	7.4
6	ASIAN JOURNAL OF CHEMISTRY	482	477	0.153	0.066	467	9.4
7	JOURNAL OF THE INDIAN CHEMICAL SOCIETY	472	1922	0.34	0.062	257	>10.0
8	JOURNAL OF APPLIED POLYMER SCIENCE	428	24233	1.072	0.142	1142	8.8
9	INDIAN JOURNAL OF CHEMISTRY SECTION B-ORGANIC CHEMISTRY INCLUDING MEDICINAL CHEMISTRY	412	2284	0.446	0.055	271	NA
10	INDIAN JOURNAL OF AGRICULTURAL SCIENCES	406	470	0.084	0	153	5.3
11	JOURNAL OF FOOD SCIENCE AND TECHNOLOGY-MYSORE	377	810	0.123	0	139	3.8
12	PHYSICAL REVIEW B	331	199350	3.185	0.609	6126	>10.0
13	INDIAN JOURNAL OF PHYSICS AND PROCEEDINGS OF THE INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE	286	342	0.072	0.02	202	>10.0
14	INDIAN JOURNAL OF CHEMISTRY SECTION A-INORGANIC BIO-INORGANIC PHYSICAL THEORETICAL & ANALYTICAL CHEMISTRY	255	2033	0.632	0.103	195	4.9
15	INDIAN JOURNAL OF PURE & APPLIED PHYSICS	253	821	0.495	0.026	152	6.6
16	PRAMANA-JOURNAL OF PHYSICS	248	781	0.38	0.153	216	5.5
17	JOURNAL OF APPLIED PHYSICS	237	88927	2.498	0.363	3453	4.3
18	SPECTROCHIMICA ACTA PART A-MOLECULAR AND BIOMOLECULAR SPECTROSCOPY	209	5613	1.29	0.17	593	8.5
19	PHYSICAL REVIEW D	208	82935	4.852	1.749	2247	>10.0
20	INDIAN JOURNAL OF HETEROCYCLIC CHEMISTRY	207	287	0.312	0.024	127	9.2
21	JOURNAL OF PHYSICAL CHEMISTRY B	204	59826	4.033	0.705	3121	>10.0
22	SYNTHETIC COMMUNICATIONS	202	6344	0.86	0.126	404	4.5
23	JOURNAL OF MOLECULAR CATALYSIS A-CHEMICAL	197	9227	2.348	0.417	599	7.5
24	JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	197	850	0.217	0.08	150	6.2
25	BULLETIN OF MATERIALS SCIENCE	196	754	0.777	0.026	117	5.3
26	PHYSICAL REVIEW LETTERS	193	250517	7.489	1.572	3694	>10.0
27	TETRAHEDRON	184	39659	2.61	0.493	1222	7.8
28	JOURNAL OF SCIENTIFIC & INDUSTRIAL RESEARCH	184	453	0.232	0.016	123	5
29	INDIAN JOURNAL OF CHEMICAL TECHNOLOGY	172	288	0.226	0.04	101	6.6
30	JOURNAL OF THE INDIAN ACADEMY OF PEDIATRICS*	167	NA	NA	NA	NA	5.9
31	CHEMICAL PHYSICS LETTERS	167	48249	2.438	0.519	1393	7.7
32	PHYSICAL REVIEW E	165	48497	2.418	0.5	2525	>10.0
33	JOURNAL OF CHEMICAL PHYSICS	164	148396	3.138	0.71	2902	8
34	PHYSICA B-CONDENSED MATTER	160	9394	0.796	0.14	1041	4.2
35	MATERIALS LETTERS	160	5812	1.299	0.173	873	6.6
36	NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS	159	12230	1.181	0.115	1341	5.2
37	MOLECULAR AND CELLULAR BIOCHEMISTRY	156	6127	1.681	0.161	316	5.3
38	JOURNAL OF MATERIALS SCIENCE	155	15674	0.901	0.088	831	5
39	BIOORGANIC & MEDICINAL CHEMISTRY LETTERS	155	14580	2.478	0.573	1076	5.2
40	MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING	151	15537	1.347	0.17	1196	7.7
41	APPLIED PHYSICS LETTERS	149	123517	4.127	0.551	4414	1.7
42	TRANSACTIONS OF THE INDIAN INSTITUTE OF METALS	148	161	0.215	0.017	116	5.3
43	BIORESOURCE TECHNOLOGY	147	4456	1.863	0.287	265	
44	JOURNAL OF PHYSICS-CONDENSED MATTER	142	22209	2.145	0.358	1172	9.2
45	INDIAN JOURNAL OF MEDICAL RESEARCH	137	1497	0.869	0.476	124	3.8
46	PHYSICS LETTERS B	135	55129	5.301	1.499	955	>10.0
47	JOURNAL OF COLLOID AND INTERFACE SCIENCE	135	24877	2.023	0.305	973	6.9
48	INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	135	15264	1.504	0.221	1106	6.9
49	JOURNAL OF ENVIRONMENTAL BIOLOGY	134	229	0.34	0	119	7.4
50	BIOORGANIC & MEDICINAL CHEMISTRY	130	7484	2.286	0.577	662	>10.0

India Journal
*** 2007 Journal Citation Reports (released in mid 2008) will be listed with an impact factor.**

TABLE 7. TOP 25 EC JOURNALS CONTAINING MOST ARTICLES BY INDIA AUTHORS

EC Records - Journal Publications (2005 - 2006)					
Serial Title	**2005 Records**	**Journal IF**	**Serial Title**	**2006 Records**	**Journal IF**
Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	223	NA	Journal Of Applied Polymer Science	266	1.072
Pramana - Journal Of Physics	151	0.38	Proceedings Of Spie - The International Society For Optical Engineering	195	NA
Journal Of Food Science And Technology	123	0.123	Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	154	NA
Journal Of Applied Polymer Science	119	1.072	Journal Of Food Science And Technology	136	0.123
Spectrochimica Acta - Part A: Molecular And Biomolecular Spectroscopy	118	1.29	Pramana - Journal Of Physics	118	0.38
Journal Of Applied Physics	114	2.498	Journal Of Molecular Catalysis A: Chemical	114	2.348
Bulletin Of Materials Science	101	0.777	Journal Of Applied Physics	112	2.498
Journal Of Physical Chemistry B	97	4.033	Spectrochimica Acta - Part A: Molecular And Biomolecular Spectroscopy	102	1.29
IEEE International Conference On Personal Wireless Communications	88	NA	Journal Of Physical Chemistry B	99	4.033
Proceedings Of SPIE - The International Society For Optical Engineering	86	NA	Bulletin Of Materials Science	95	0.777
Physica B: Condensed Matter	85	0.796	Journal Of Materials Science	94	0.901
2006 IEEE Power India Conference	85	NA	Bioresource Technology	93	NA
Materials Science And Engineering A	80	1.347	Journal Of Physics Condensed Matter	92	2.145
Ferroelectrics	78	NA	Applied Physics Letters	91	4.127
Lecture Notes In Computer Science	77	NA	Journal Of Chemical Physics	91	3.138
Journal Of Materials Science	76	0.901	Journal Of Hazardous Materials	85	NA
Chemical Physics Letters	76	2.438	Chemical Physics Letters	85	2.438
Materials Letters	75	1.299	Industrial And Engineering Chemistry Research	83	1.504
Proceedings Of Indicon 2005: An International Conference Of IEEE India Council	73	NA	Materials Letters	81	1.299
Journal Of Chemical Physics	72	3.138	Materials Science And Engineering A	78	1.347
Journal Of Molecular Catalysis A: Chemical	71	2.348	International Journal Of Advanced Manufacturing Technology	77	NA
Materials Chemistry And Physics	68	NA	Journal Of Colloid And Interface Science	74	2.023
Industrial And Engineering Chemistry Research	68	1.504	Journal Of Physics D: Applied Physics	73	NA

TABLE 8. TOP 25 INSPEC JOURNALS CONTAINING MOST ARTICLES BY INDIA AUTHORS

INSPEC Records - Journal Publications (2005 - 2006)					
Serial Title	**2005 Records**	**Journal IF**	**Serial Title**	**2006 Records**	**Journal IF**
Current Science	165	0.728	Journal of Applied Polymer Science	127	1.072
Pramana, Journal of Physics	146	0.38	Current Science	114	0.728
Indian Journal of Pure and Applied Physics	141	0.495	Physical Review B Condensed Matter and Materials Physics	113	3.185
Spectrochimica Acta, Part A Molecular and Biomolecular Spectroscopy	122	1.29	Nuclear Instruments Methods In Physics Research, Section B Beam Interactions With Materials and Atoms	111	1.181
Physical Review B Condensed Matter and Materials Physics	113	3.185	Pramana, Journal of Physics	100	0.38
Journal of Applied Physics	101	2.498	2006 IFIP International Conference on Wireless and Optical Communications Networks	99	NA
Bulletin of Materials Science	100	0.777	2006 IEEE Power India Conference	97	NA
Journal of Scientific and Industrial Research	94	0.232	Journal of Physics: Condensed Matter	91	2.145
Transactions of The Indian Institute of Metals	94	0.215	Journal of Scientific and Industrial Research	91	0.232
2005 IEEE International Conference On Personal Wireless Communications	91	NA	Journal of Applied Physics	90	2.498
Ferroelectrics	90	NA	Applied Physics Letters	83	4.127
Physica B	84	0.796	Materials Letters	83	1.299
Chemical Physics Letters	81	2.438	Indian Journal of Pure and Applied Physics	79	0.495
Journal of Materials Science	80	0.901	Journal of Materials Science	77	0.901
Materials Science Engineering A Structural Materials: Properties, Microstructure and Processing	77	1.347	Spectrochimica Acta, Part A Molecular and Biomolecular Spectroscopy	74	1.29
Materials Letters	74	1.299	Materials Science Engineering A Structural Materials: Properties, Microstructure and Processing	73	1.347
Proceedings of 2005 International Conference On Intelligent Sensing and Information Processing	68	NA	Bulletin of Materials Science	71	0.777
Physical Review E Statistical, Nonlinear, and Soft Matter Physics	65	2.418	Journal of Chemical Physics	70	3.138
Indian Journal of Chemical Technology	64	0.226	Journal of Physics D Applied Physics	68	NA
Journal of Crystal Growth	64	NA	Surface Coatings Technology	66	NA
Journal of Applied Polymer Science	63	1.072	Journal of Physical Chemistry B	64	4.033
Journal of Physical Chemistry B	63	4.033	Applied Surface Science	63	NA
Pattern Recognition and Machine Intelligence. First International Conference, PREMI 2005 Proceedings	61	NA	Materials Chemistry and Physics	63	NA

3.2.2 Most Cited Journals

The aggregate journal citation metrics comprise total citations from all research articles retrieved from the SCI/SSCI database during the period (2005-2006). The Top 50 journals cited most frequently were identified, and are presented in Table 9, sorted in order of decreasing citation frequency.

TABLE 9. TOP 50 MOST CITED JOURNALS BY INDIAN AUTHORS

SCI / SSCI Journal Bibliometrics (2005 - 2006)							
Rank	JOURNALS	# Records	2005 Total Cites	Impact Factor	Immediacy Index	2005 Articles	Cited Half-Life
1	JOURNAL OF THE INDIAN ACADEMY OF PEDIATRICS*	167	NA	NA	NA	NA	5.9
2	PHYSICAL REVIEW LETTERS	193	250517	7.489	1.572	3694	>10.0
3	PHYSICAL REVIEW B	331	199350	3.185	0.609	6126	>10.0
4	JOURNAL OF CHEMICAL PHYSICS	164	148396	3.138	0.71	2902	8
5	APPLIED PHYSICS LETTERS	149	123517	4.127	0.551	4414	1.7
6	JOURNAL OF APPLIED PHYSICS	237	88927	2.498	0.363	3453	4.3
7	PHYSICAL REVIEW D	208	82935	4.852	1.749	2247	>10.0
8	TETRAHEDRON LETTERS	574	69531	2.477	0.532	1956	7.6
9	JOURNAL OF PHYSICAL CHEMISTRY B	204	59826	4.033	0.705	3121	>10.0
10	PHYSICS LETTERS B	135	55129	5.301	1.499	955	>10.0
11	PHYSICAL REVIEW E	165	48497	2.418	0.5	2525	>10.0
12	CHEMICAL PHYSICS LETTERS	167	48249	2.438	0.519	1393	7.7
13	TETRAHEDRON	184	39659	2.61	0.493	1222	7.8
14	JOURNAL OF COLLOID AND INTERFACE SCIENCE	135	24877	2.023	0.305	973	6.9
15	JOURNAL OF APPLIED POLYMER SCIENCE	428	24233	1.072	0.142	1142	8.8
16	JOURNAL OF PHYSICS-CONDENSED MATTER	142	22209	2.145	0.358	1172	9.2
17	JOURNAL OF MATERIALS SCIENCE	155	15674	0.901	0.088	831	5
18	MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING	151	15537	1.347	0.17	1196	7.7
19	INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	135	15264	1.504	0.221	1106	6.9
20	BIOORGANIC & MEDICINAL CHEMISTRY LETTERS	155	14580	2.478	0.573	1076	5.2
21	NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS	159	12230	1.181	0.115	1341	5.2
22	PHYSICA B-CONDENSED MATTER	160	9394	0.796	0.14	1041	4.2
23	JOURNAL OF MOLECULAR CATALYSIS A-CHEMICAL	197	9227	2.348	0.417	599	7.5
24	BIOORGANIC & MEDICINAL CHEMISTRY	130	7484	2.286	0.577	662	>10.0
25	SYNTHETIC COMMUNICATIONS	202	6344	0.86	0.126	404	4.5
26	MOLECULAR AND CELLULAR BIOCHEMISTRY	156	6127	1.681	0.161	316	5.3
27	MATERIALS LETTERS	160	5812	1.299	0.173	873	6.6
28	SPECTROCHIMICA ACTA PART A-MOLECULAR AND BIOMOLECULAR SPECTROSCOPY	209	5613	1.29	0.17	593	8.5
29	BIORESOURCE TECHNOLOGY	147	4456	1.863	0.287	265	
30	CURRENT SCIENCE	774	3451	0.728	0.294	537	6.2
31	ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	547	3322	0.581	0.325	2849	7.4
32	INDIAN JOURNAL OF CHEMISTRY SECTION B-ORGANIC CHEMISTRY INCLUDING MEDICINAL CHEMISTRY	412	2284	0.446	0.055	271	NA
33	INDIAN JOURNAL OF CHEMISTRY SECTION A-INORGANIC BIO-INORGANIC PHYSICAL THEORETICAL & ANALYTICAL CHEMISTRY	255	2033	0.632	0.103	195	4.9
34	JOURNAL OF THE INDIAN CHEMICAL SOCIETY	472	1922	0.34	0.062	257	>10.0
35	INDIAN JOURNAL OF MEDICAL RESEARCH	137	1497	0.869	0.476	124	3.8
36	INDIAN JOURNAL OF ANIMAL SCIENCES	602	1051	0.09	0.016	312	5.7
37	JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	197	850	0.217	0.08	150	6.2
38	INDIAN JOURNAL OF PURE & APPLIED PHYSICS	253	821	0.495	0.026	152	6.6
39	JOURNAL OF FOOD SCIENCE AND TECHNOLOGY-MYSORE	377	810	0.123	0	139	3.8
40	INDIAN VETERINARY JOURNAL	747	800	0.052	0.009	438	>10.0
41	PRAMANA-JOURNAL OF PHYSICS	248	781	0.38	0.153	216	5.5
42	BULLETIN OF MATERIALS SCIENCE	196	754	0.777	0.026	117	5.3
43	ASIAN JOURNAL OF CHEMISTRY	482	477	0.153	0.066	467	9.4
44	INDIAN JOURNAL OF AGRICULTURAL SCIENCES	406	470	0.084	0	153	5.3
45	JOURNAL OF SCIENTIFIC & INDUSTRIAL RESEARCH	184	453	0.232	0.016	123	5
46	INDIAN JOURNAL OF PHYSICS AND PROCEEDINGS OF THE INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE	286	342	0.072	0.02	202	>10.0
47	INDIAN JOURNAL OF CHEMICAL TECHNOLOGY	172	288	0.226	0.04	101	6.6
48	INDIAN JOURNAL OF HETEROCYCLIC CHEMISTRY	207	287	0.312	0.024	127	9.2
49	JOURNAL OF ENVIRONMENTAL BIOLOGY	134	229	0.34	0	119	7.4
50	TRANSACTIONS OF THE INDIAN INSTITUTE OF METALS	148	161	0.215	0.017	116	5.3

Table 9 clearly indicates that the Impact Factors for these most cited journals are an order of magnitude higher than the Impact Factors of the journals that contain the most India papers. Thus, India authors are citing the high Impact Factor journals extensively, but not publishing in them extensively. Although it can be shown that India authors are increasing their presence in these high Impact Factor journals, they are presently over-concentrated in the lower Impact Factor journals. Table 9 also clearly indicates the distribution of most cited Indian journals (highlighted) relative to all most cited journals. The most cited Indian journals are all distributed towards the lowest total of 2005 cites, and only account for approximately 1.3% (18,301) of the total 2005 cites (1,436,677).

3.3 Prolific Affiliations

This section provides detailed bibliometric analysis results that identify not only the most prolific affiliations associated with India authors, but also which affiliations collaborate significantly on research publications. The analysis specifically identifies these most prolific affiliations (institutions) and their collaboration linkages (based on total number of articles) through use of several methods including:

1) Affiliation Co-occurrence Matrices
2) Affiliation Auto-correlation Maps
3) Affiliation Factor Matrices, and

Additional methods are employed to identify specific affiliation collaboration linkages (based on common terminology and Journals) including:

4) Affiliation - Phrase Co-occurrence Matrices
5) Affiliation x Phrase Cross-correlation Maps
6) Affiliation-Journal Co-occurrence Matrices

The analysis presented in the following paragraphs use each of these methods independently to provide progressive insight into the nature or attributes of specific research collaboration groups (links). Each of these methods are integral to the TechOasis software package and allow detailed correlation analysis between research article attributes (data fields) including authors, affiliations, subject categories, keywords and journals. It is noted below however, that the utility of these methods when employed for the EC and INSPEC database is limited since the retrieved articles only provide one author/affiliation address per article. Therefore, the EC and INSPEC co-occurrence matrices are symmetric with values of one (1) along the diagonal yielding no information on collaboration linkages. Likewise, EC and INSPEC auto-correlation maps show no connected publishing groupings or linkages, however these maps are still useful since information associated with authors, subject categories, keyword and journals can be extracted and compared to SCI/SSCI maps. Each method listed above is described in the following paragraphs.

3.3.1 Most Prolific Affiliations

Figures 18 through 20 previously showed the most prolific author affiliations (gross bibliometrics) relative to the total number of records published within the (2005-2006) period, for the SCI/SSCI, EC and INSPEC databases, respectively. The affiliations comprise research institutes, laboratories, universities and industry, as discussed above in Section 1.1.4 (Indian Science and Technology System), and as listed in Table 10. Two institutions stand out in terms of productivity: 1) Indian Institute of Technology (IIT) and 2) Indian Institute of Science. However, it should be noted that output of IIT is the total aggregate of seven IITs as listed in Appendix A, Table 8. Several IITs were established with financial assistance and technical expertise from UNESCO, Germany, the United States, and Russia, and there are current plans to establish three additional IITs in Rajasthan, Bihar and Andhra Pradesh, increasing the total number to ten (10).

3.3.2 Affiliation - Affiliation Co-Occurrence

This section provides analysis results that address which affiliations collaborate significantly on publications. To identify cross- affiliation collaboration, a co-occurrence matrix (affiliation x affiliation) was generated from the retrieved SCI/SSCI 2005-2006 database (using the TechOasis software). The co-occurrence matrix results for the Top 25 affiliations are provided in Table 11. Since the EC and INSPEC databases only provide one author affiliation per record, similar co-occurrence matrices were not generated for comparison. The EC and INSPEC matrices are symmetric with values of one (1) along the diagonal.

The major collaborators for the top five affiliations from Table 10 (SCI/SSCI column) are as follows (collaborator/ [# articles]):

1. Indian Institute of Technology (Bhabha Atom Res Ctr [85], Indian Inst Sci [70], Tata Inst Fundamental Res [66], Inst Phys [46], and Natl Inst Technol [43]).

2. Indian Institute of Science (Jawaharlal Nehru Ctr Adv Sci Res [97], IIT [70], Tata Inst Fundamental Res [29], Univ. Madras [29], and Univ. Mysore [20]).

3. Bhabha Atom Res Ctr (IIT [85], Banaras Hindu Univ. [34], Inst High Energy Phys [33], Tata Inst Fundamental Res [31], and Tokyo Inst Technol [30]).

4. Univ Delhi (Tata IFR [53], Inst High Energy Phys [50], Univ. Texas [49], Punjab Univ. [48], and Univ. Cal. Berkeley 48]).

5. Institute of Chemical Technology (Univ. Madras [52], Bharathidasan Univ. [18], Sri Venkateswara Univ. [17], Osmania Univ. [13], and Karnatak Univ. [12]).

For example, Indian Institute of Technology (aggregated output of six IITs) and Tata Institute of Fundamental Research collaborated on 66 research articles. To display these linkages or groupings more graphically, an auto-correlation map was generated based on the affiliations listed in Table 10 (SCI/SSCI column), and will be discussed in the following section.

TABLE 10. TOP 25 AUTHOR AFFILIATIONS (2005 - 2006)

	SCI / SSCI Total Records		INSPEC Total Records		EC Total Records	
Rank	Institution Name	% of 52047	Institution Name	% of 18988	Institution Name	% of 24475
1	Indian Institute of Technology	12.41%	Indian Institute of Technology	5.55%	Indian Institute of Technology	6.64%
2	Indian Institute of Science	4.32%	Indian Institute of Science	3.34%	Indian Institute of Science	2.70%
3	Bhabha Atomic Research Centre	2.61%	Tata Institute of Fundamental Research	0.71%	Bhabha Atomic Research Centre	0.61%
4	Univ. of Delhi	1.92%	National Physical Laboratory	0.48%	Regional Research Laboratory	0.41%
5	Institute Of Chemical Technology	1.87%	Raman Research Institute	0.36%	National Chemical Laboratory	0.38%
6	Tata Institute of Fundamental Research	1.70%	Indian Institute of Astrophysics	0.35%	Central Electrochemical Research Institute	0.33%
7	All India Institute of Medical Science	1.61%	Institute of Physics	0.34%	Tata Institute of Fundamental Research	0.31%
8	Jadavpur Univ.	1.61%	Physical Research Laboratory	0.34%	National Physical Laboratory	0.26%
9	National Chemical Laboratory	1.58%	Saha Institute of Nuclear Physics	0.33%	Institute of Physics	0.26%
10	Banaras Hindu Univ.	1.51%	National Geophysical Research Institute	0.32%	National Institute Of Oceanography	0.25%
11	Univ. Madras	1.35%	Banaras Hindu Univ.	0.31%	National Metallurgical Laboratory	0.23%
12	Anna Univ.	1.26%	Univ. of Delhi	0.28%	Univ. of Delhi	0.20%
13	Indian Assoc Cultivat Sci	1.20%	National Chemical Laboratory	0.27%	Mahatma Gandhi Univ.	0.19%
14	Panjab Univ.	1.02%	Harish-Chandra Research Institute	0.27%	Saha Institute of Nuclear Physics	0.19%
15	Aligarh Muslim Univ.	1.01%	Sri Venkateswara Univ.	0.26%	Crystal Growth Centre, Anna Univ.	0.18%
16	CSIR	0.98%	Institute of Mathematics and Science	0.26%	Aligarh Muslim Univ.	0.18%
17	Indian Stat Institute	0.96%	National Metallurgical Laboratory	0.25%	Institute Of Chemical Technology	0.18%
18	Univ. Hyderabad	0.94%	Central Electrochemical Research Institute	0.23%	Physical Research Laboratory	0.17%
19	Postgrad Institute Medical Education & Research	0.90%	Shivaji Univ.	0.22%	Anna Univ.	0.13%
20	Univ. Calcutta	0.90%	Osmania Univ.	0.22%	Defence Metallurgical Research Lab.	0.11%
21	Natl Institute of Technology	0.87%	Cochin Univ. of S&T	0.11%	Institute for Plasma Research	0.09%
22	Univ. Mysore	0.86%	Institute for Plasma Research	0.09%	Sardar Patel Univ.	0.09%
23	Annamalai Univ.	0.77%	Bharathiar Univ.	0.09%	Banaras Hindu Univ.	0.08%
24	Saha Institute Of Nuclear Physics	0.77%	Aligarh Muslim Univ.	0.09%	Raman Research Institute	0.08%
25	Cent Drug Research Institute	0.72%	Defence Metallurgical Research Lab.	0.09%	National Geophysical Research Institute	0.08%

TABLE 11. SCI/SSCI TOP 25 AFFILIATIONS CO-OCCURRENCE MATRIX RESULTS

		Affiliations (Name):Top 50	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		# Records	6111	2151	1295	964	939	860	843	777	773	747	678	607	591	510	507	483	471	465	445	438	436	429	380	375	352
Affiliations (Name):Top 50	# Records		Indian Inst Technol	Indian Inst Sci	Bhabha Atom Res Ctr	Univ Delhi	Indian Inst Chem Technol	Jadavpur Univ	Tata Inst Fundamental Res	All India Inst Med Sci	Natl Chem Lab	Banaras Hindu Univ	Univ Madras	Anna Univ	Indian Assoc Cultivat Sci	Panjab Univ	Aligarh Muslim Univ	CSIR	Univ Hyderabad	Indian Stat Inst	Univ Calcutta	Univ Mysore	Postgrad Inst Med Educ & Re	Natl Inst Technol	Saha Inst Nucl Phys	Annamalai Univ	Cent Drug Res Inst
1	6111	Indian Inst Technol	6111	70	85	27	5	39	66	10	20	24	3	12	8	30	5	11	11	11	14	1	1	43	7		5
2	2151	Indian Inst Sci	70	2151	16	4	2	10	29	4	4	5	29	1	10	1	1	5	16	9	1	20		4	4	2	2
3	1295	Bhabha Atom Res Ctr	85	16	1295	8	1	3	31	1	5	34		5		17	2	4	4		3	1		1	18		
4	964	Univ Delhi	27	4	8	964	1	3	53	14		5			3	48	1	4	3		1	2			7		1
5	939	Indian Inst Chem Technol	5	2	1	1	939				5	1	52			7	1	2	7			1		3		6	4
6	860	Jadavpur Univ	39	10	3	3		860	5		1	1			26		1		1	16	37	1	1	4	6		2
7	843	Tata Inst Fundamental Res	66	29	31	53		5	843		1	6	1		5	135	2		3	1	7			1	11	1	1
8	777	All India Inst Med Sci	10	4	1	14				777				1		1	4	8			1		1				
9	773	Natl Chem Lab	20	4	5		5	1	1		773		1	1	1			3	1					1	1		1
10	747	Banaras Hindu Univ	24	5	34	5	1	1	6			747				2	2	1	1					4	2		4
11	678	Univ Madras	3	29			52		1		1		678	47					2	2		5			1	2	
12	607	Anna Univ	12	1	5					1	1		47	607				1								5	
13	591	Indian Assoc Cultivat Sci	8	10		3		26	5		1				591		1				9	1		1	11		1
14	510	Panjab Univ	30	1	17	48	7		135	1		2				510		1			1		11	1	1		
15	507	Aligarh Muslim Univ	5	1	2	1	1	1	2	4		2			1		507	2			1						6
16	483	CSIR	11	5	4	4	2			8	3	1		1		1	2	483			1			1		3	1
17	471	Univ Hyderabad	11	16	4	3	7	1	3		1	1	2						471	2							
18	465	Indian Stat Inst	11	9				16	1				2						2	465	9		1		1		
19	445	Univ Calcutta	14	1	3	1		37	7	1					9	1	1	1		9	445		2		18		
20	438	Univ Mysore	1	20	1	2	1	1					5		1							438				1	
21	436	Postgrad Inst Med Educ & Res	1					1		1						11				1	2		436				1
22	429	Natl Inst Technol	43	4	1		3	4	1		1	4			1	1		1						429			
23	380	Saha Inst Nucl Phys	7	4	18	7		6	11		1	2	1		11	1				1	18				380		
24	375	Annamalai Univ		2			6		1				2	5				3				1				375	
25	352	Cent Drug Res Inst	5	2		1	4	2	1		1	4			1		6	1					1				352

3.3.3 Affiliation Auto-Correlation Maps

Figures 39 through 41 provide auto-correlation maps of the Top 25 prolific institutions listed in Table 10 (generated by the TechOasis software) for the SCI/SSCI, EC and INSPEC (2005–2006) databases, respectively. No strongly connected publishing groupings or even linkages are evident within the SCI/SSCI auto-correlation map (Figure 39), but four moderately connected publishing groupings can be identified:

- Tata Institute of Fundamental Research - centered group (top center)
- Indian Institute of Science - centered group (left center)
- National Geophysical Research Institute (NGRI), Hyderabad - centered group (bottom center)
- Because of its sheer magnitude, the Indian Institute of Technology (actually, an aggregate of six IITs within the country) has to be included as a self-contained group

Similar auto-correlation maps were generated for the EC and INSPEC database records for the period (2005-2006) as shown in Figures 40 and 41, respectively. However, since the EC and INSPEC databases only provide one author affiliation per record, the maps show no connected publishing groupings or even linkages. The EC and INSPEC auto-correlation maps are useful; however, since information associated with authors, subject categories, keyword and journals was extracted and compared to the SCI/SSCI auto-correlation maps as discussed below.

As discussed above, the Tata Institute of Fundamental Research it a leading affiliation based on consistent growth of publication retrieved from the SCI/SSCI, EC and INSPEC databases for the time period 2005-2006, in addition to the overall growth trend displayed over the extended 1980-2005 time period (Refer to Section 3.1.1.2 Publication Trends - Author Affiliations). As such, this affiliation was selected for additional analysis and the following groups of figures attempt to provide a comparison of the authors, keywords, journals and subject categories associated with this select affiliation for all three databases. Figures 42 through 44 compare the associated authors and uncontrolled keywords for SCI/SSCI, EC and INSPEC databases, respectively. Figures 45 through 47 compare the associated journals and subject categories for SCI/SSCI, EC and INSPEC databases, respectively.

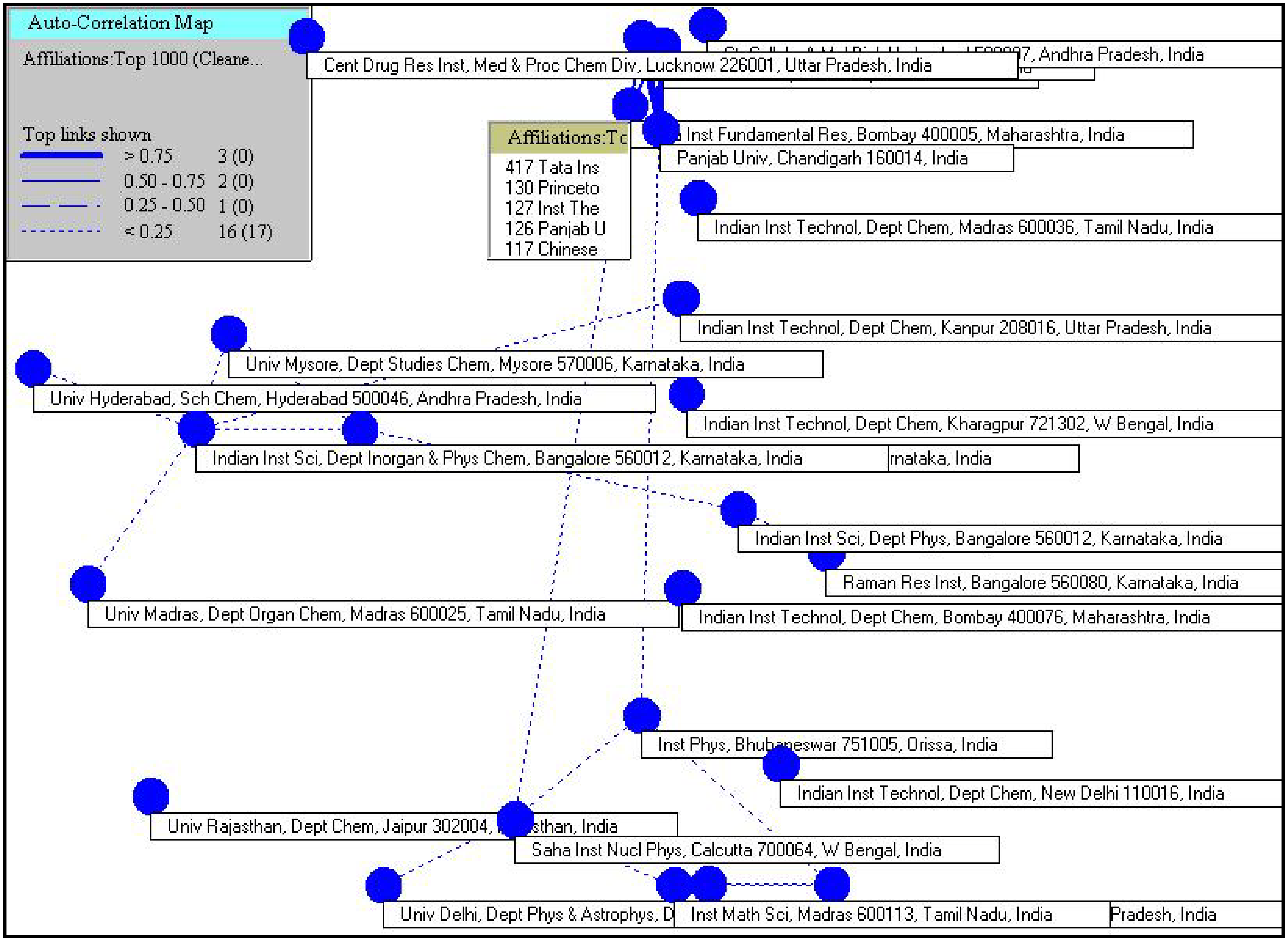

Figure 39. SCI/SSCI Affiliations (Top 25) Auto-Correlation Map

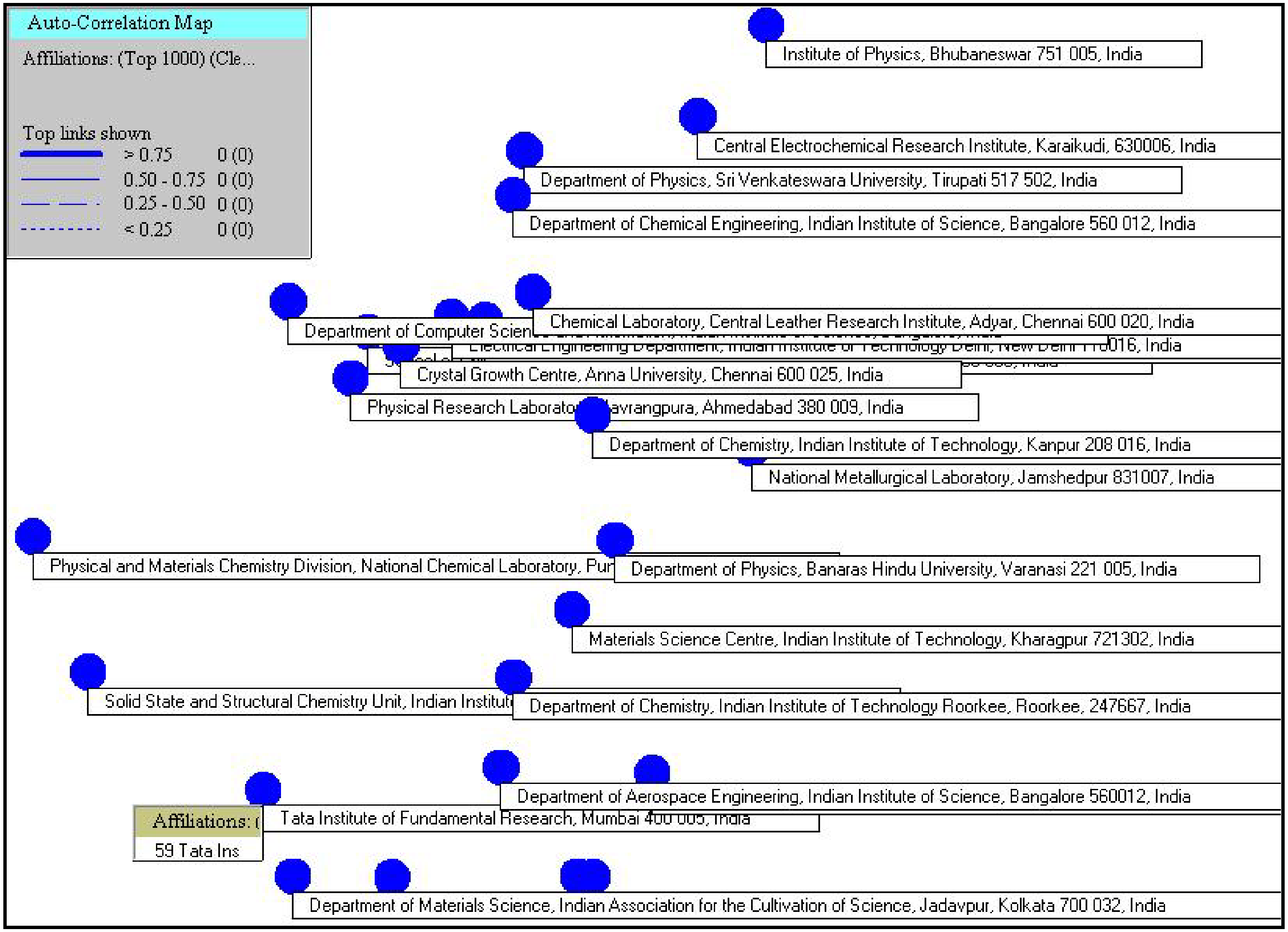

Figure 40. EC Affiliations (Top 25) Auto-Correlation Map

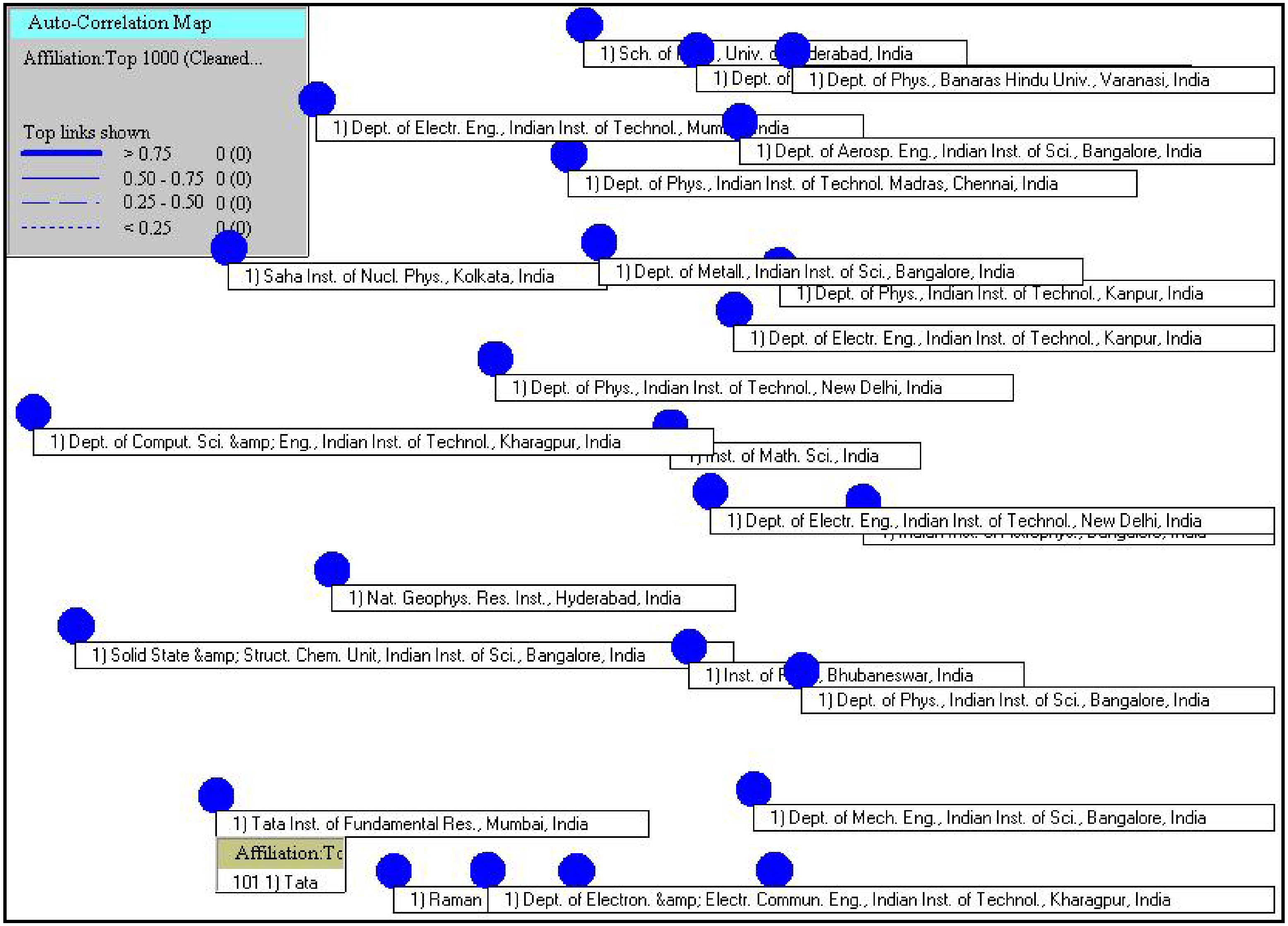

Figure 41. INSPEC Affiliations (Top 25) Auto-Correlation Map

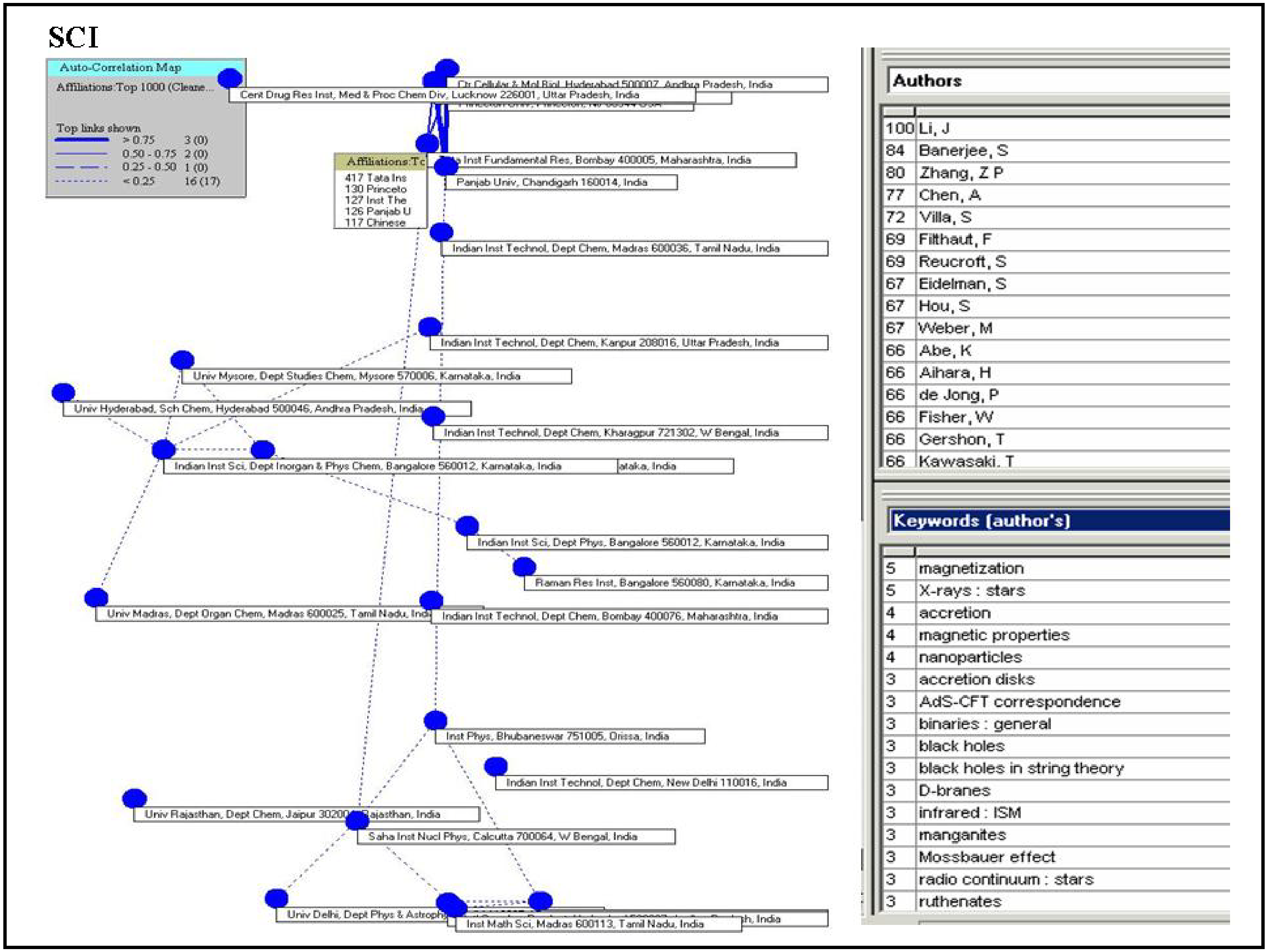

Figure 42. SCI/SSCI Auto-Correlation Map (Authors / Keywords)

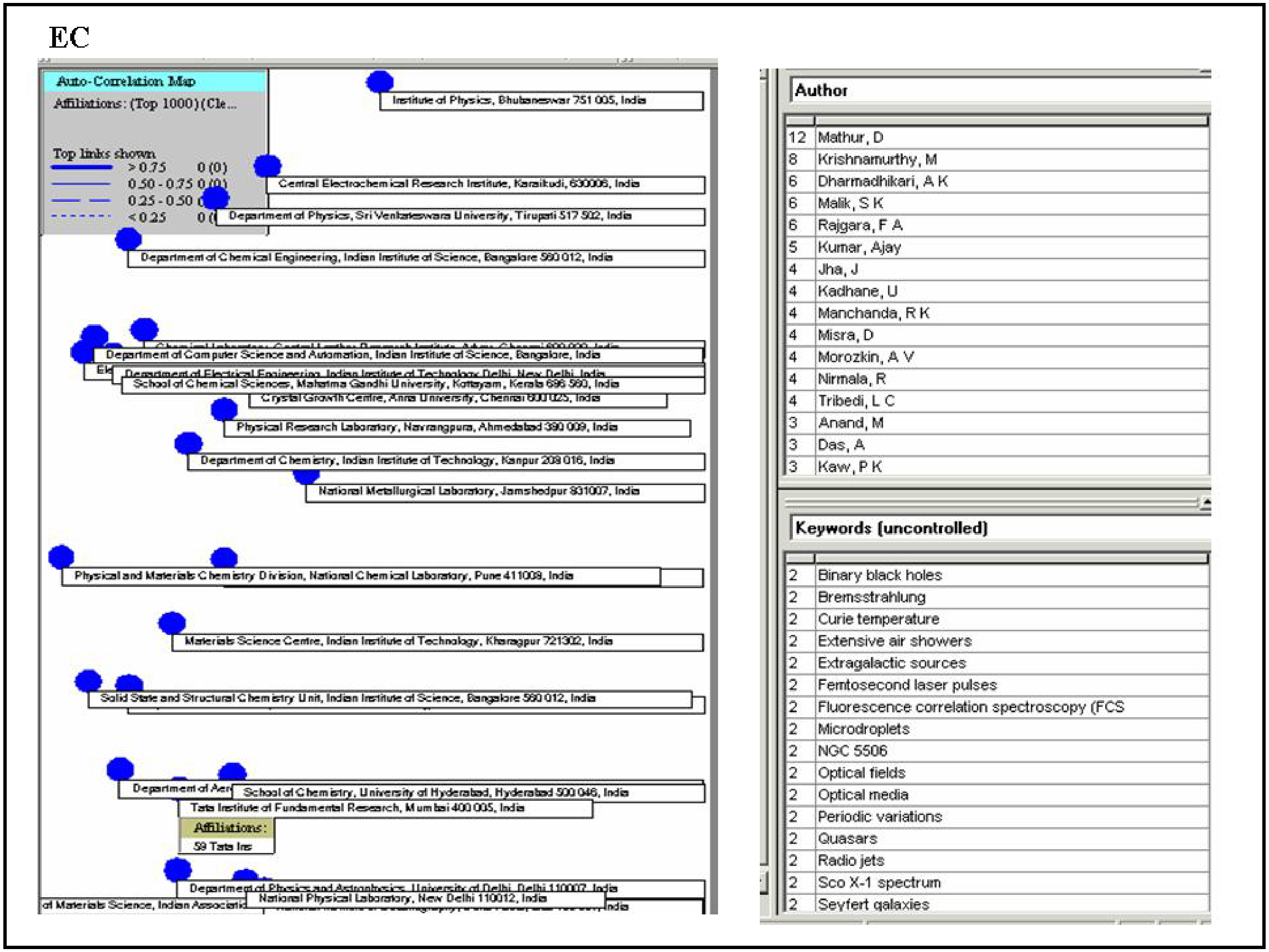

Figure 43. EC Auto-Correlation Map (Authors / Keywords)

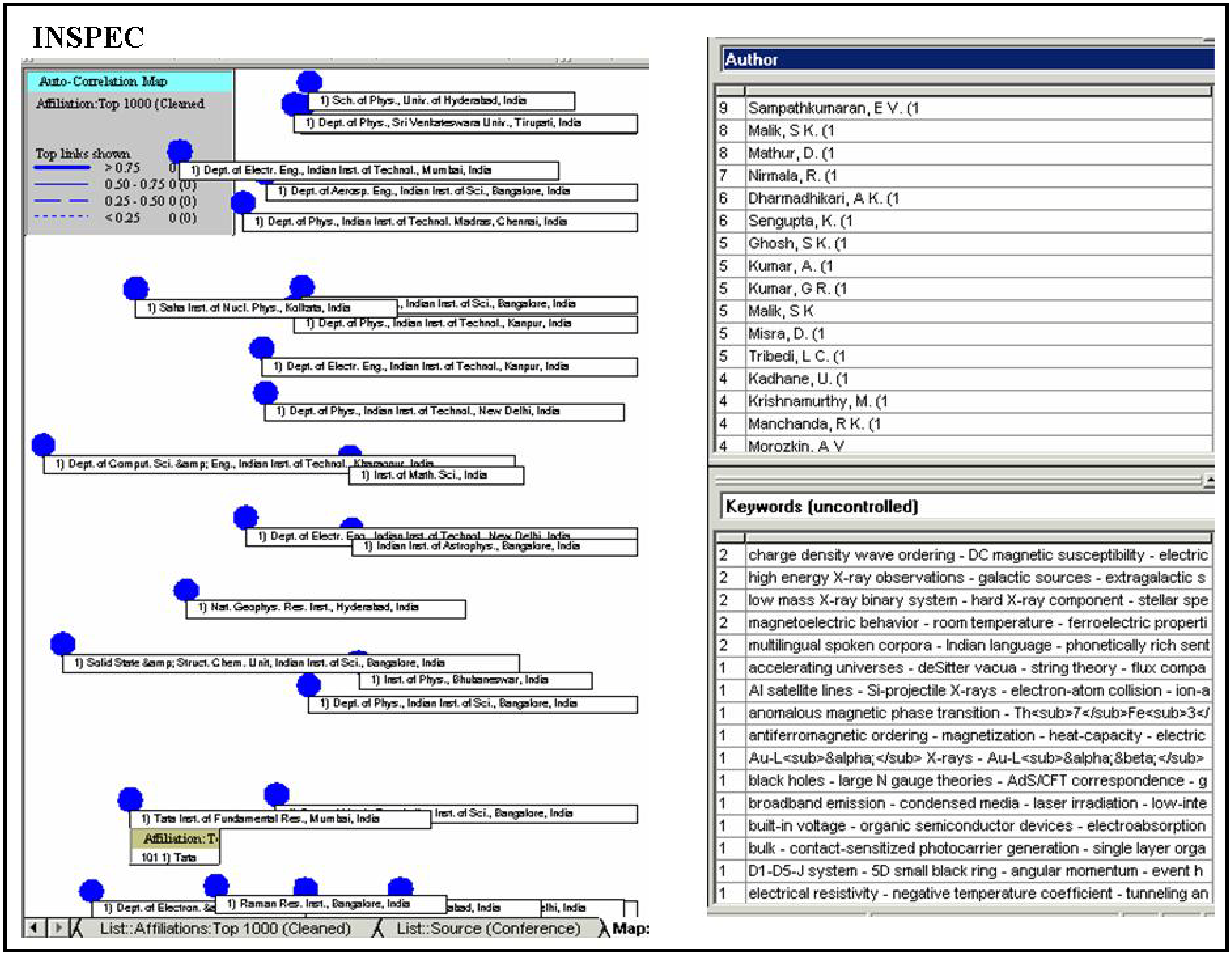

Figure 44. INSPEC Auto-Correlation Map (Authors / Keywords)

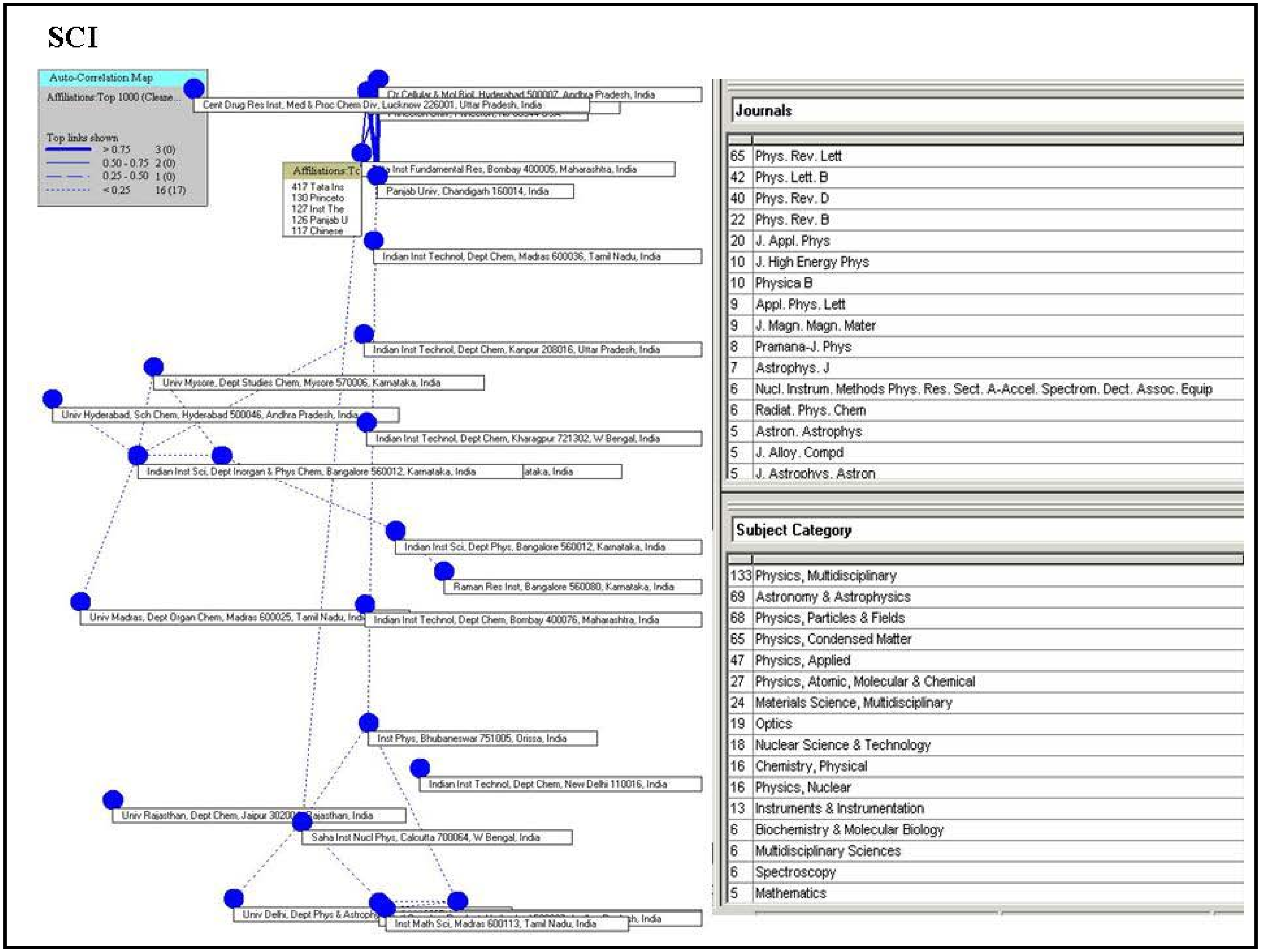

Figure 45. SCI/SSCI Auto-Correlation Map (Journals / Subject Categories)

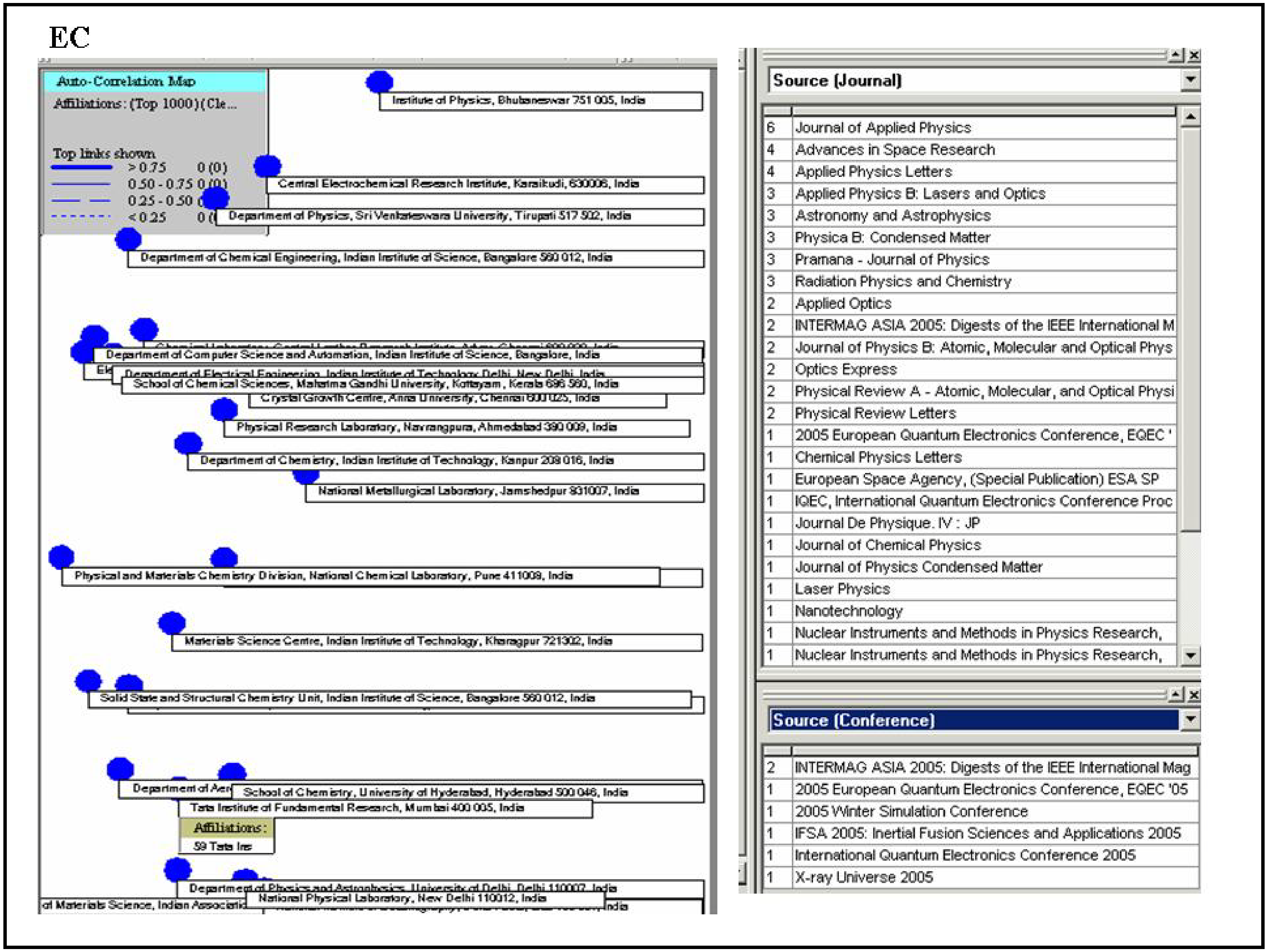

Figure 46. EC Auto-Correlation Map (Journals / Subject Categories)

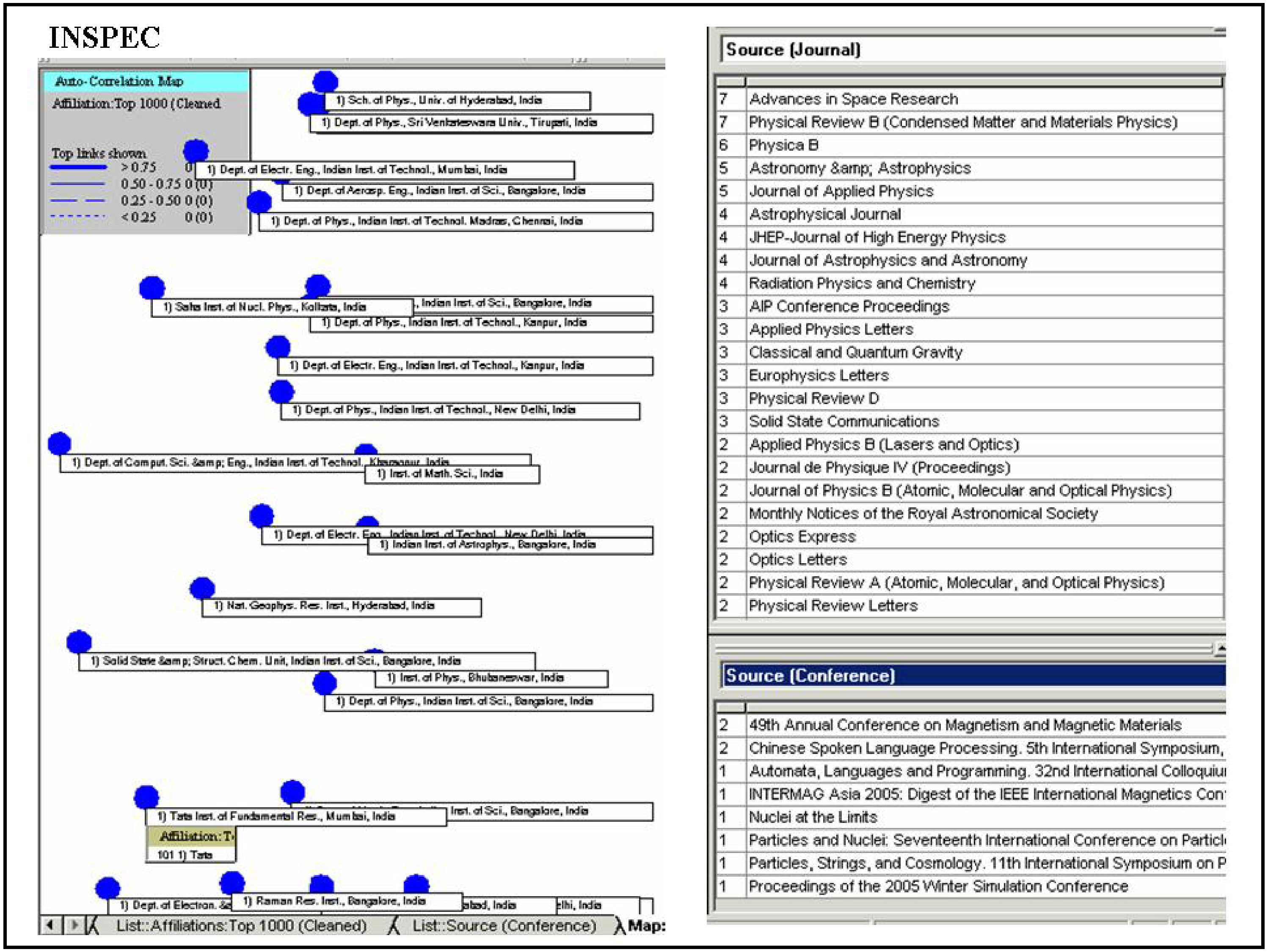

Figure 47. INSPEC Auto-Correlation Map (Journals / Subject Categories)

In summary, the SCI/SSCI Auto-Correlation Maps shown in Figures 39, 42 and 45 depict moderately connected publishing groupings or intra-connection within the four discrete groups. There is also reasonable inter-connection across these four groups evident from these maps. The two most prolific producers of research articles (Indian Institute of Technology and Indian Institute of Science) now also show external connections on these specific maps, as opposed to the preceding study that indicated no connections, *given the selected threshold connectivity level for displaying linkages.* To display these four groupings and associated linkages more quantitatively, a factor analysis was performed on the affiliations listed in Table 10 (SCI/SSCI column). Factor analysis is an analysis of the relatedness of list items (affiliations), and only multi-valued fields are suitable for the analysis. List items that have only one value per record are not well suited for factor analysis, as is the case with EC and INSPEC affiliation items. Therefore, comparative factor analysis was not performed using EC and INSPEC database records. The SCI/SSCI results are presented in the following paragraph.

3.3.4 Affiliation Factor Matrices

Based on the 25 affiliations listed in Table 10, and on the roughly four groupings discerned from the auto-correlation map of Figures 39, 42 and 45, a five factor affiliation factor matrix was generated (using the TechOasis software) and is provided in Table 12. As a rule-of-thumb, the number of factors is initially chosen as the square root of the number of prolific affiliations (25) included in the analysis. The affiliation names listed in Table 10 constitute the first column of Table 12, and the factors are the remaining columns. Each factor represents a 'theme', a group of institutions that co-author significantly. The matrix entries (the factor loadings) represent the contribution of the particular institution to the factor 'theme'. The main institutions in each factor (the 'theme') are those that have the highest absolute values of factor loadings. In determining the 'theme' for each factor, the factor column is sorted in both ascending and descending order. The tail with the highest absolute values of factor loadings determines the 'theme'. Typically, one tail is dominant, and there is one theme per factor. On rare occasions, the tails are of similar absolute value magnitude, and both tails are treated as separate 'themes'. The high factor loadings that determine each factor's theme are shaded darkly, and the moderate factor loadings that represent modest/ weak connectivity are shaded lightly.

TABLE 12. SCI/SSCI PROLIFIC AFFILIATION 5 FACTOR MATRIX (2000-2006)

	Factor	1	2	3	4	5
	Cumulative Variance	4.948	9.442	13.875	18.133	22.335
	Variance	4.948	4.494	4.433	4.257	4.202
Rank	Affiliations:Top 25 (Cleaned)	1	2	3	4	5
1	Panjab Univ	-0.719	-0.024	0.061	-0.145	-0.007
2	Tata Inst Fundamental Res	-0.704	-0.045	0.023	-0.156	0.016
3	Univ Delhi	-0.369	0.008	0.026	0.083	0.052
4	Postgrad Inst Med Educ & Res	-0.046	0.046	-0.015	0.091	0.035
5	Saha Inst Nucl Phys	-0.038	-0.28	-0.343	0.064	-0.128
6	Bhabha Atom Res Ctr	-0.03	-0.538	0.091	0.187	-0.169
7	Indian Inst Sci	-0.014	0.475	0.03	0.183	0.245
8	Univ Mysore	0.003	0.242	0.015	0.149	0.104
9	All India Inst Med Sci	0.005	0.055	0.06	0.281	0.113
10	Univ Calcutta	0.006	-0.111	-0.572	-0.101	-0.023
11	Univ Hyderabad	0.007	0.142	0.038	0.106	0.064
12	Indian Assoc Cultivat Sci	0.01	0.013	-0.373	0.013	0.042
13	Indian Inst Chem Technol	0.019	0.19	0.056	-0.019	-0.426
14	Annamalai Univ	0.022	0.057	0.028	0.095	-0.084
15	CSIR	0.023	0	0.066	0.223	0.057
16	Aligarh Muslim Univ	0.024	-0.037	0.029	0.239	0.038
17	Cent Drug Res Inst	0.025	-0.033	0.025	0.189	0.007
18	Indian Stat Inst	0.032	0.123	-0.238	-0.044	0.08
19	Univ Madras	0.041	0.297	0.044	-0.14	-0.612
20	Banaras Hindu Univ	0.042	-0.424	0.111	0.291	-0.129
21	Jadavpur Univ	0.048	0.015	-0.564	-0.147	0.078
22	Natl Chem Lab	0.056	-0.008	0.054	0.129	0.017
23	Anna Univ	0.061	0.097	0.044	-0.155	-0.51
24	Natl Inst Technol	0.077	-0.024	0.064	-0.128	0.068
25	Indian Inst Technol	0.228	-0.22	0.308	-0.691	0.304

Five distinct groupings are shown, one for each factor.

1. Factor 1 - Panjab University strongly linked to the Tata Institute of Fundamental Research; and weakly linked to the University of Delhi and Indian Institute of Technology (IIT).

2. Factor 2 - Bhabha Atomic Research Center strongly linked to the Indian Institute of Science, Bangalore and Banaras Hindu University; and weakly linked to the Saha Institute of Nuclear Physics, University of Mysore, University of Madras, and IIT.

3. Factor 3 - University of Calcutta strongly linked to Jadavpur University; and weakly linked to the Saha Institute of Nuclear Physics, Indian Association for the Cultivation of Science, Kolkata, and the Indian Statistical Institute, and IIT.

4. Factor 4 - Indian Institute of Technology (IIT) weakly linked to the CSIR, Aligarh Muslim University, Banaras Hindu University and the All India Institute of Medical Science, and CSIR.

5. Factor 5 - University of Madras strongly linked to the Indian Institute of Chemical Technology (IICT), Hyderabad; and weakly linked to the Indian Institute of Technology (IIT) and Indian Institute of Science, Bangalore.

Thus, the main groupings from the auto-correlation institution maps are essentially reproduced in the five-factor matrix, with some additional information provided on the very weak linkages (especially for Indian Institute of Technology). Table 12 was generated based on the top 25 research article-producing affiliations only. However, this base of affiliations may not be sufficiently broad to display some of the more interesting linkages.

To incorporate more affiliations into the analysis, while retaining mostly domestic affiliations, a ten (10) factor matrix based on the 100 most prolific research article producers was generated, and is shown in Table 13. It should be noted that Table 13 only lists the affiliations (50 of 100) that show clear and defined linkages. Note however that the overall ranking (Column 1), relative to the total number of records/papers published, were preserved from the original list of the Top 100 prolific affiliations. Again, the high factor loadings that determine each factor's theme are shaded darkly, and the moderate factor loadings that represent modest/ weak connectivity are shaded lightly.

TABLE 13. SCI/SSCI PROLIFIC AFFILIATION TEN FACTOR MATRIX (2005 - 2006)

	Factor	1	2	3	4	5	6	7	8	9	10
	Cumulative Variance	6.477	8.536	10.113	11.356	12.536	13.709	14.854	15.983	17.101	18.218
	Variance	6.477	2.059	1.577	1.243	1.179	1.173	1.144	1.129	1.118	1.116
Rank	Affiliations (Name):Top 25	1	2	3	4	5	6	7	8	9	10
1	Indian Inst Technol					0.356		-0.374	0.26	-0.399	
2	Univ Rajasthan			-0.48							
3	Ctr Nucl Sci		-0.196						-0.284	0.227	
4	Univ Jammu			-0.625							
5	Jawaharlal Nehru Ctr Adv Sci Res					-0.543	-0.252				
6	Inst Phys			-0.597							
7	Bhabha Atom Res Ctr		-0.304							0.318	
8	Indira Gandhi Ctr Atom Res		-0.21								
9	Banaras Hindu Univ		-0.246								
12	Anna Univ		-0.225					0.414			
15	Aligarh Muslim Univ								-0.311		
16	Univ Illinois				-0.454						-0.531
20	Tata Inst Fundamental Res				-0.43						
21	Indian Assoc Cultivat Sci						0.222				
22	Univ Tokyo		-0.24		-0.657						0.299
24	Natl Phys Lab								-0.405		
27	Jadavpur Univ						0.413				
28	Bharathidasan Univ							0.285			
32	Univ Calcutta						0.453				
42	Cent Drug Res Inst		0.323								
43	Maharaja Sayajirao Univ Baroda									0.206	
44	Univ Lucknow		0.218								
45	Korea Univ				-0.891						
46	Univ Madras							0.536			
47	Indian Inst Sci					-0.624	-0.304				
49	Ind Toxicol Res Ctr		0.255								
52	Univ Texas		0.228	-0.331	-0.279						-0.557
54	Saha Inst Nucl Phys		-0.182				0.422				
56	Sanjay Gandhi Postgrad Inst Med Sci		0.237								
60	Univ Burdwan						0.279				
63	Indian Inst Chem Biol						0.28				
64	Tokyo Inst Technol		-0.241		-0.707						0.309
65	Panjab Univ			-0.235	-0.531						
66	Jamia Millia Islamia								-0.489		
68	Univ Calif Berkeley		0.211	-0.355	-0.325						-0.586
70	Jawaharlal Nehru Univ								-0.292		
76	Indian Inst Chem Technol							0.452			
79	Inst High Energy Phys			-0.226	-0.876						-0.225
81	Bose Inst						0.267				
82	Tohoku Univ				-0.619						0.354
83	CNRS				-0.228						-0.544
85	Inst Theoret & Expt Phys				-0.9						
86	Princeton Univ				-0.873						
89	Univ Sci & Technol China			-0.265	-0.844						
91	Univ Delhi								-0.368		-0.316
93	Univ Poona									0.445	
96	Natl Chem Lab									0.448	
98	Univ Frankfurt	-0.374		-0.55	-0.276						
99	Mangalore Univ	-0.689									
100	Univ Mysore	-0.75									

The results of the 10-factor matrix are as follows:

1. Factor 1 indicates a new linkage comprising the University of Mysore strongly linked to Mangalore University and weakly linked to the University of Frankfurt.

2. Factor 2 essentially mirrors Factor 2 from the Five Factor Matrix comprising affiliations involved in atomic and nuclear research. A new linkage is evident comprising affiliations involved in medical research including Central Drug Research Institute, India Toxicology Research Center, University of Lucknow, and Sanjay Gandhi Postgraduate Institute of Medical Sciences.

3. Factors 3 indicates a new linkage and represent international collaboration probably in high energy physics (based on the institutions listed).

4. Factors 4 also indicates a new linkage and represent international collaboration probably in high energy physics (based on the institutions listed).

5. Factor 5 indicates a new linkage comprising the Indian Institute of Science strongly linked to Jawaharlal Nehru Center for Advanced Scientific Research and weakly linked to the Indian Institute of Technology (IIT).

6. Factor 6 essentially mirrors Factor 3 from the Five Factor Matrix, with the addition of a new grouping or linkage comprising the Indian Institute of Science, Indian Institute of Chemical Biology (IICB) Calcutta, Jawaharlal Nehru University, Bose Institute and the University of Burdwan. This new linkage may represent international collaboration probably in chemical research (based on the institutions listed).

7. Factor 7 essentially mirrors Factor 5 from the Five Factor Matrix, with the addition of Anna University and Bharathidasan University.

8. Factor 8 indicates a new linkage comprising Jamia Millia Islamia (National Islamic University, New Delhi) strongly linked to the National Physics Laboratory, University of Delhi, and Aligarh Muslim University; and weakly linked to Jawaharlal Nehru University, Center for Nuclear Science, and the Indian Institute of Technology (IIT).

9. Factor 9 indicates a new linkage comprising the National Chemistry Laboratory strongly linked to University of Poona; and weakly linked to the Indian Institute of Technology (IIT) and the Bhabha Atomic Research Center.

10. Factor 10 indicates two new linkages comprising: 1) University of California, Berkeley strongly linked to the University of Texas, Centre National de la Recherche Scientifique (CNRS) / National Center for Scientific Research, and University of Illinois; and 2) Tohoku University strongly linked to the Tokyo Institute of Technology, Institute of High Energy Physics, and the University of Delhi.

While this section and the previous two sections portray affiliation linkages from a number of perspectives, they offer little insight as to why the affiliations are linked; in particular, what are the specific technical themes on which they collaborate. The next series of results presented in the following section attempts to portray affiliation linkages based on commonality of subject matter (e.g., subject categories, author keywords, technical phrases, etc.), and provides another important part of the overall bibliometric analysis.

3.3.5 Affiliation - Phrase Co-Occurrence Matrix

To identify affiliation linkages based on common use of technical terminology, affiliation-phrase co-occurrence matrices were generated (using the TechOasis software) for each database. Tables 14a, 14b and 14c provide sections of the total co-occurrence matrices (based on total articles) for the SCI/SSCI, EC and INSPEC databases (2005-2006), respectively. The sections for each matrix comprise the Top ten (10) author keywords (detailed phrases) for the Top ten (10) affiliations.

TABLE 14A. SCI/SSCI AFFILIATION - PHRASE CO-OCCURRENCE MATRIX (2005 - 2006)

Affiliation	Total Records	SCI/SSCI Co-occurrence Matrix Top 10 Affiliations - Top 10 Detailed Phrases	SCI/SSCI Co-Occurrence Matrix Top 10 Affiliations - Top 10 Detailed Phrases									
Indian Inst Technol	6111	Keywords	microstructure	adsorption	X-ray diffraction	crystal structure	finite element method	simulation	genetic algorithm	optimization	sintering	modeling
		Cooccurrence # of Records	51	51	43	36	34	32	32	30	28	27
Indian Inst Sci	2151	Keywords	crystal structure	X-ray diffraction	India	oxides	friction	thin films	electrical properties	Mycobacterium tuberculosis	hydrogen bonds	degradation
		Cooccurrence # of Records	27	26	10	10	10	9	9	9	8	8
Bhabha Atom Res Ctr	1295	Keywords	pulse radiolysis	X-ray diffraction	thermal expansion	high pressure	lipid peroxidation	crystal structure	antioxidant	nanoparticles	solvent extraction	neutron diffraction
		Cooccurrence # of Records	22	21	16	14	14	11	11	11	10	10
Univ Delhi	964	Keywords	sol-gel	microwave irradiation	singular equation	cyclic voltammetry	IR	1	RMS errors	H-1 NMR	thin films	ionic liquid
		Cooccurrence # of Records	18	10	9	9	9	9	8	7	7	7
Indian Inst Chem Technol	939	Keywords	water	beta-cyclodextrin	1	pervaporatio n	amines	alpha	2	heterogeneous catalyst	membrane characterization	alcohols
		Cooccurrence # of Records	27	21	21	18	15	14	13	12	11	10
Jadavpur Univ	860	Keywords	crystal structure	QSAR	X-ray structure	vanadium	kinetics	magnetic properties	microemulsion	electrochemistry	ultrafiltration	X-ray crystal structure
		Cooccurrence # of Records	23	17	11	9	9	9	9	9	8	8
Tata Inst Fundamental Re	843	Keywords	X-rays : stars	accretion	accretion disks	magnetic properties	magnetization	stars : neutron	D-branes	black holes in string theory	peak effect	black holes
		Cooccurrence # of Records	12	10	8	7	7	6	6	6	6	5
All India Inst Med Sci	777	Keywords	crystal structure	tuberculosis	breast cancer	immunohisto-chemistry	oxidative stress	Indian population	body temperature	apoptosis	children	haplotype
		Cooccurrence # of Records	11	10	9	8	8	7	7	7	7	6
Natl Chem Lab	773	Keywords	electron microscopy	ceramics	chemical synthesis	X-ray diffraction	oxides	XRD	electronic materials	X-ray methods	XPS	nanoparticles
		Cooccurrence # of Records	37	31	26	23	23	16	13	12	11	11
Banaras Hindu Univ	747	Keywords	melatonin	microstructure	aging	India	visceral leishmaniasis	adsorption	apoptosis	catfish	upconversion	yield
		Cooccurrence # of Records	9	8	8	7	7	7	7	7	6	6

TABLE 14B. EC AFFILIATION - PHRASE CO-OCCURRENCE MATRIX (2005 - 2006)

Ranking	Affiliation	Total Records	EC Co-occurrence Matrix Top 10 Affiliations - Top 20 Detailed Phrases										
1	Department of Aerospace Engineering, Indian Institute of Science, Bangalore	142	Keywords	Mathematical models	Synthesis (chemical)	Computer simulation	X ray diffraction analysis	Algorithms	Scanning electron microscopy	Optimization	Reaction kinetics	Thermal effects	X ray diffraction
			Cooccurrence # of Records	34	3	18	3	7	5	4	2	3	1
2	Department of Chemical Engineering, Indian Institute of Science, Bangalore	131	Keywords	Mathematical models	Computer simulation	Reynolds number	Drag	Elasticity	Concentration (process)	Granular materials	Nucleation	Approximation theory	Reaction kinetics
			Cooccurrence # of Records	34	18	2	2	5	2		2	3	2
3	Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore	82	Keywords	Synthesis (chemical)	Computer simulation	Molecular dynamics	X ray diffraction analysis	Crystal structure	X ray diffraction	Mathematical models	Diffusion	Electric conductivity	Phase transitions
			Cooccurrence # of Records	18	14	11	9	8	8	8	7	7	7
4	Central Electrochemical Research Institute, Karaikudi	66	Keywords	Electrochemistry	Corrosion resistance	Scanning electron microscopy	X ray diffraction analysis	X ray diffraction	Electrodeposition	Oxidation	Fourier transform infrared spectroscopy	Corrosion inhibitors	Electrodes
			Cooccurrence # of Records	13	11	11	11	7	7	7	7	6	6
5	National Physical Laboratory, New Delhi	60	Keywords	Sol-gels	Nanostructured materials	Scanning electron microscopy	Lattice constants	X ray diffraction	X ray diffraction analysis	Annealing	Synthesis (chemical)	Electrochromism	Crystallization
			Cooccurrence # of Records	11	10	9	8	8	8	8	7	7	6
6	Tata Institute of Fundamental Research, Mumbai	59	Keywords	Ionization	Laser pulses	X rays	Computer simulation	Spectrum analysis	Electrons	Scintillation counters	Laser beam effects	X ray analysis	Magnetization
			Cooccurrence # of Records	8	8	7	6	5	5	4	4	4	4
7	Institute of Physics, Bhubaneswar	59	Keywords	Transmission electron microscopy	Nanostructured materials	Silicon	Ion implantation	Rutherford backscattering spectroscopy	Thin films	Ion beams	Raman scattering	Heavy ions	Irradiation
			Cooccurrence # of Records	23	15	10	10	9	8	8	7	7	7
8	School of Chemistry, University of Hyderabad, Hyderabad	56	Keywords	Molecular structure	Reaction kinetics	Crystal structure	Solvents	Synthesis (chemical)	Fluorescence	Hydrogen bonds	Complexation	Positive ions	Spectroscopic analysis
			Cooccurrence # of Records	10	8	8	8	8	8	7	7	6	5
9	Department of Chemistry, Indian Institute of Technology, Roorkee	56	Keywords	Oxidation	pH effects	Complexation	Synthesis (chemical)	Titration	Polystyrenes	Polyvinyl chlorides	Catalysts	Adsorption	Electrochemistry
			Cooccurrence # of Records	19	13	12	9	8	8	8	7	7	7
10	Physical and Materials Chemistry Division, National Chemical Laboratory, Pune	55	Keywords	Transmission electron microscopy	Synthesis (chemical)	X ray diffraction analysis	Precipitation (chemical)	Particle size analysis	Ceramic materials	Nanostructured materials	X ray diffraction	Electron microscopy	Ammonium compounds
			Cooccurrence # of Records	35	28	18	18	17	16	16	15	15	9

TABLE 14C. INSPEC AFFILIATION - PHRASE CO-OCCURRENCE MATRIX (2005 - 2006)

Ranking	Affiliation	Total Records	INSPEC Co-occurrence Matrix Top 10 Affiliations - Top 20 Detailed Phrases										
1	Dept. of Physics, Indian Institute of Science, Bangalore	166	Keywords	films	temperature	optical properties	sample	reconstructed image	transition	density	noisy artifacts	range	values
			Cooccurrence # of Records	16	15	12	11	9	8	8	8	8	7
2	Dept. of Comput. Sci. & Eng., Indian Institute of Technology, Kharagpur	128	Keywords	network	speed	simulation	methods	effectiveness	problems	concept	surface	image	article
			Cooccurrence # of Records	12	9	8	7	7	7	7	6	6	6
3	Tata Institute of Fundamental Research, Mumbai	101	Keywords	compound	source	magnitude	electrical resistivity	existence	technique	vicinity	measurements	evolution	5 K
			Cooccurrence # of Records	10	7	6	6	6	5	5	5	5	4
4	Dept. of Electr. Eng., Indian Institute of Technology, New Delhi	100	Keywords	effectiveness	motor	point	simulation	simulation results	control	starting	proposed algorithm	reluctance motor SRM	three-phase
			Cooccurrence # of Records	10	7	7	7	7	7	7	6	6	5
5	Dept. of Electr. Eng., Indian Institute of Technology, Kanpur	84	Keywords	voltage	simulation results	effectiveness	noise	operation	impact	technique	inverter	development	devices
			Cooccurrence # of Records	9	6	5	5	5	4	4	4	4	4
6	Raman Research Institute, Bangalore	82	Keywords	galaxies	groups	Eridanus group	formation	GMRT observations	group	Universe	fraction	summary form	synthesis
			Cooccurrence # of Records	15	13	12	10	9	9	8	7	7	6
7	Dept. of Aerosp. Eng., Indian Institute of Science, Bangalore	77	Keywords	wave propagation	controller	agents	noise	potential	problems	formulation	genetic algorithm	simple	thrust
			Cooccurrence # of Records	7	7	6	5	5	5	5	5	5	4
8	Solid State & Struct. Chem. Unit, Indian Institute of Science, Bangalore	76	Keywords	structure	temperature	transition	water	magnetic properties	molecules	films	formation	crystal structures	interactions
			Cooccurrence # of Records	14	13	6	6	6	6	6	6	5	5
9	Physics Research Laboratory, Ahmedabad	72	Keywords	Delta	general	dynamics	networks	synchronizatio n	temperature	threshold	isotopic composition	values	Bay
			Cooccurrence # of Records	6	6	5	5	4	4	4	4	4	4
10	Dept. of Mech. Eng., Indian Institute of Science, Bangalore	71	Keywords	article	independent	material	parametric study	predictions	flow	friction	elements	pressure drop	process
			Cooccurrence # of Records	6	6	6	6	6	6	6	5	5	5

The general trend for each database indicates that some overlap appears between the Top 10 affiliations on specific terminology, while other overlaps appear only on very generic terminology. It should be noted that the SCI/SSCI listings of affiliations are grouped, compared to the EC and INSPEC databases, that are more detailed and list individual departments within affiliations. This is due to the format and contents of the SCI/SSCI database record field for author address that do not provide this information. More affiliations, detailed phrases, and a more intuitive display are required to gain a better understanding of the bases for inter-affiliation collaboration. The next section presents such an approach based on the generation and analysis of affiliation-phrase cross-correlation maps.

3.3.6 Affiliation - Phrase Cross-Correlation Maps

To display these linkages among affiliations more visually, sets of cross-correlation maps were generated for each database (SCI/SSCI, EC and INSPEC) using the TechOasis software) that show relationships between affiliations based on use of common terminology for the period (2005-2006). The first map in each set is based on the use of a generic abstract NLP technical phrase list. The second map is based on the use of a detailed abstract NLP technical phrase list that was obtained by removing all generic phrases for the first 1000 list items (ranked by highest total records per phrase and frequency (occurrences)).

- The SCI/SSCI dataset contained 774,310 generic phrases (max. records per phrase = 12,771) and 774,136 detailed phrases (max. records per phrase = 1,757).

- The EC dataset contained 391,525 generic phrases (max. records per phrase = 18,037) and 391,243 detailed phrases (max. records per phrase = 990).

- The INSPEC dataset contained 297,885 generic phrases (max. records per phrase = 5,632) and 297,697 detailed phrases (max. records per phrase = 1,064).

One immediately observable difference between the affiliation-generic phrase map and the affiliation-detailed phrase cross-correlation maps is the number of displayed linkages and the strength of the linkages. The generic phrase maps shows stronger, less defined internal linkages than do the detailed phrase maps that show weaker, more defined linkages based on use of more specific terminology. This conveys the importance of using multiple analytical techniques when assessing bibliometrics results.

3.3.6.1 SCI/SSCI Affiliation - Phrase Cross-Correlation Maps

Figure 48 (generic phrases) and Figure 49 (detailed phrases) show the affiliation - phrase cross-correlation maps for the SCI/SSCI dataset. The cross-correlation maps indicate the affiliation collaboration structure contains significant differences from the collaboration structure shown previously in Figure 39 (SCI/SSCI Top 25 Affiliations Auto-Correlation Map). Most importantly, both cross-correlation and auto-correlation map types shows central cores of Indian research based on common terminology, with the more basic research centered about the Indian Institute of Science and the more applied research centered about the Indian Institute of Technology (IIT). One interpretation of the differences between the cross-correlation structure and the auto-correlation structure (Figure 39) is that the Indian Institute of Science and the Indian Institute of Technology are working the same general research areas as a number of other institutions, but they are not collaborating on publications to the same extent. This may be due to overlap at a generic level of technical description, but distinctness at the much more detailed level of technical description required for collaborative research and publication. Alternatively, it may be due to a tradition of more independent research and publication practices.

Numerous technically based groupings can be discerned from the SCI/SSCI cross-correlation maps including: 1) a large chemistry-oriented group at the top that includes several IIT chemistry departments, the Central Drug Research Institute and several leading universities; and 2) a strong linkage at the bottom between the Tata Institute of Fundamental Research and the Institute of Theoretical and Experimental Physics, Moscow. Note that the strong linkages of the chemistry-oriented group in Figure 48 (generic phrases), are replaced with weaker linkages in Figure 49 (detailed phrases). The maps do however retain the strong linkage between the Tata Institute of Fundamental Research and the Institute of Theoretical and Experimental Physics.

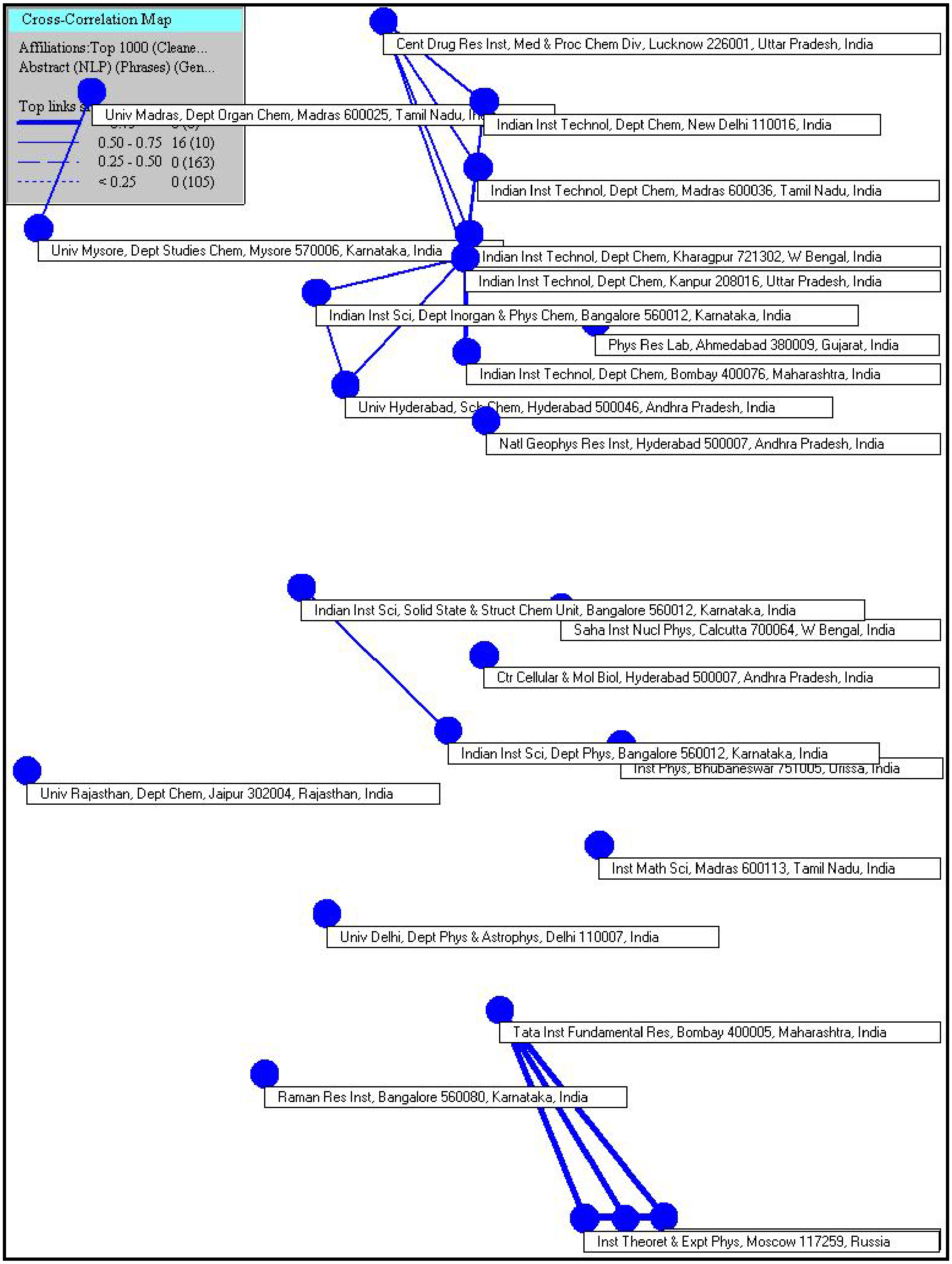

Figure 48. SCI/SSCI Cross-Correlation Map Affiliation x Generic Phrases (NLP)

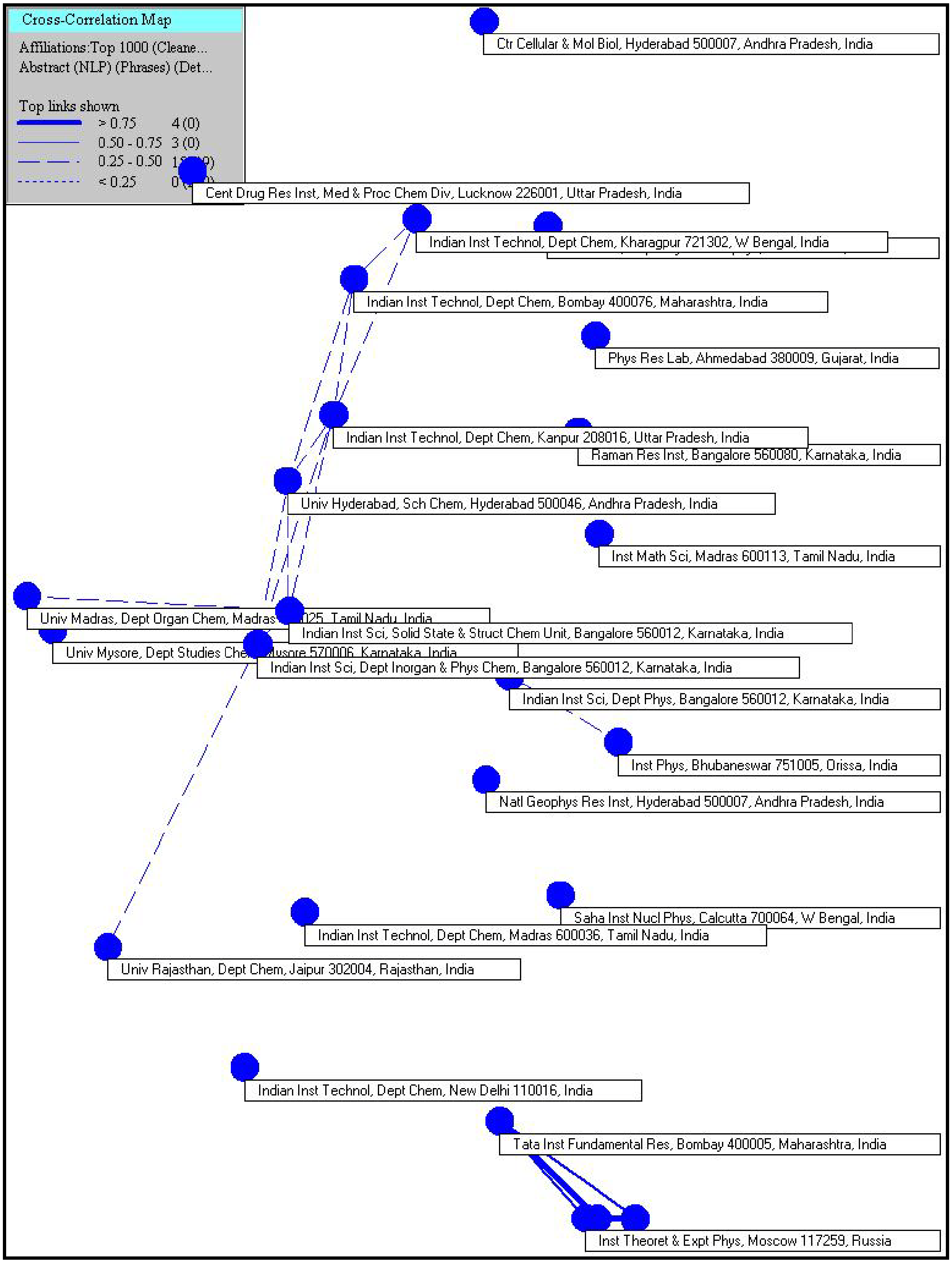

Figure 49. SCI/SSCI Cross-Correlation Map Affiliation x Detailed Phrases (NLP)

3.3.6.2 EC Affiliation - Phrase Cross-Correlation Maps

Figure 50 (generic phrases) and Figure 51 (detailed phrases) show the affiliation - phrase cross-correlation maps for the EC dataset. The cross-correlation maps indicate the affiliation collaboration structure contains significant differences from the collaboration structure shown previously in Figure 40 (EC Top 25 Affiliations Auto-Correlation Map). The previous auto-correlation structure shows no linkages since the EC database records contain only one author affiliation per record. The cross-correlation structure includes a large applied chemistry-oriented group (center) that includes several IIT and Indian Institute of Science chemistry departments, Central Electrochemical Research Institute and several leading universities. Note again that the strong linkages of this grouping shown in Figure 50 (generic phrases), are replaced with weaker linkages as a defined cluster in Figure 51 (detailed phrases).

3.3.6.3 INSPEC Affiliation - Phrase Cross-Correlation Maps

Figure 52 (generic phrases) and Figure 53 (detailed phrases) show the affiliation - phrase cross-correlation maps for the INSPEC dataset. The cross-correlation maps indicate the affiliation collaboration structure contains significant differences from the collaboration structure shown previously in Figure 41 (INSPEC Top 25 Affiliations Auto-Correlation Map). The previous auto-correlation structure shows no linkages since the INSPEC database records contain only one author affiliation per record. The cross-correlation structure includes a large applied chemistry-oriented group (center) that includes several IIT and Indian Institute of Science chemistry departments, Central Electrochemical Research Institute and several leading universities. Note again from the cross-correlation map chart legend that the weak linkages (0.25 – 0.5) of this grouping shown in Figure 52 (generic phrases), are replaced with even weaker linkages (< 0.25) as a defined cluster in Figure 49 (detailed phrases).

A more detailed examination of the collaborative practices among the affiliations listed in the SCI/SSCI, EC and INSPEC datasets might provide additional insight to these issues. ***This approach of comparing*** affiliation ***autocorrelation maps with*** affiliation ***cross-correlation maps may prove to be a powerful approach for identifying*** affiliations ***that are related by common interests, but are not collaborating accordingly.*** This auto/cross-correlation map comparison approach need not be limited to affiliations. ***It is equally applicable to authors, countries, and other categories.***

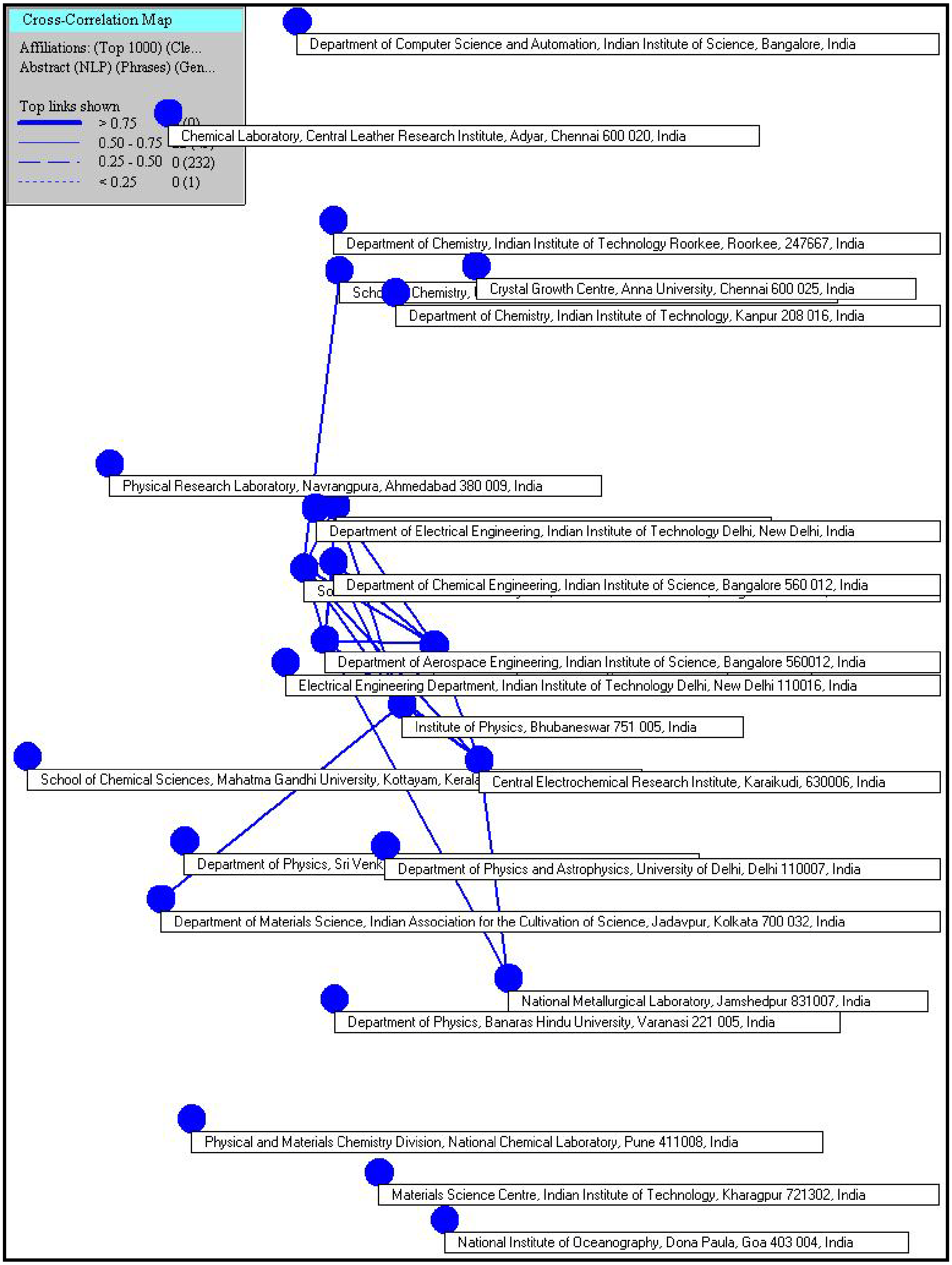

Figure 50. EC Cross-Correlation Map Affiliation x Generic Phrases (NLP)

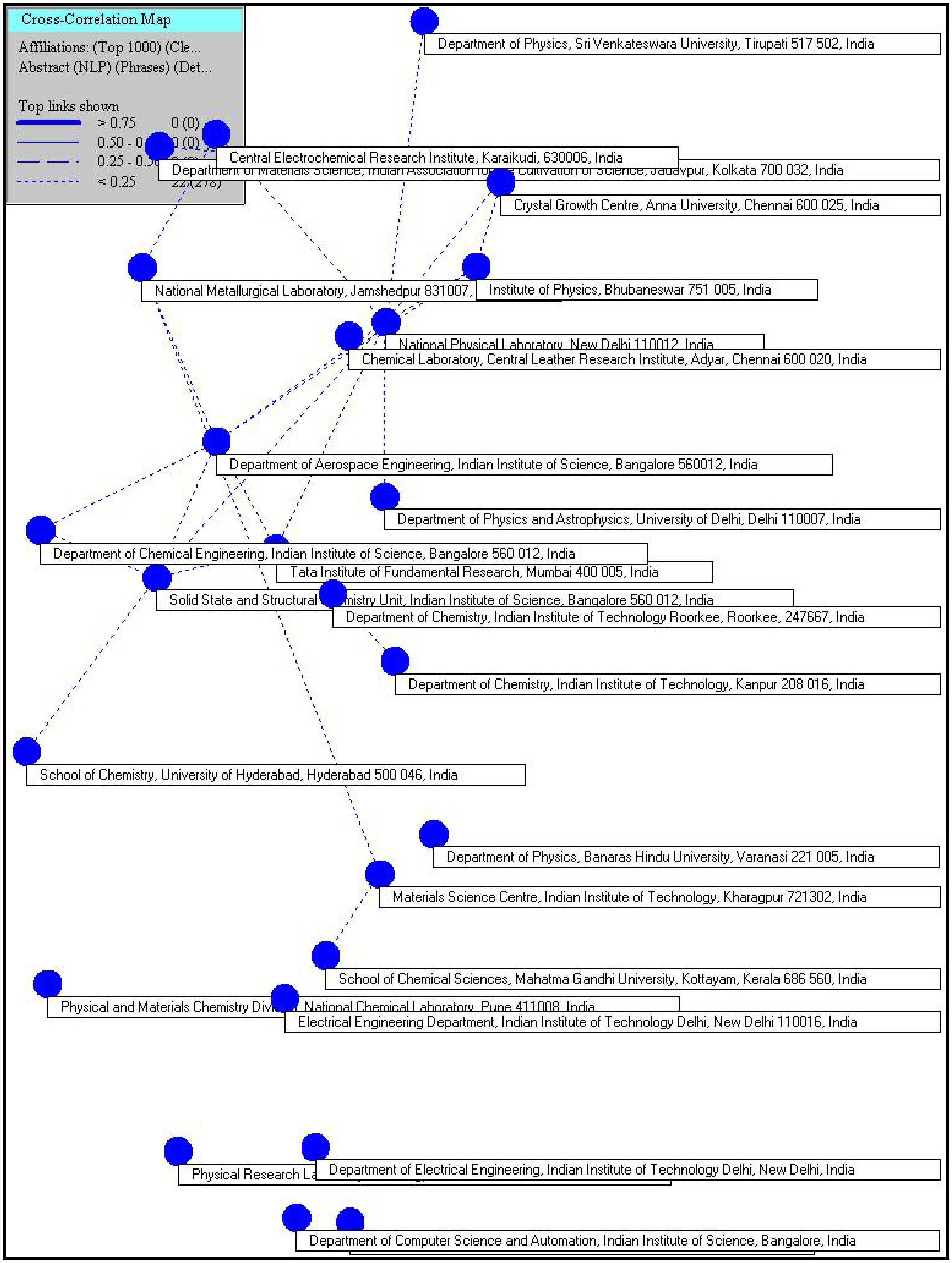

Figure 51. EC Cross-Correlation Map Affiliation x Detailed Phrases (NLP)

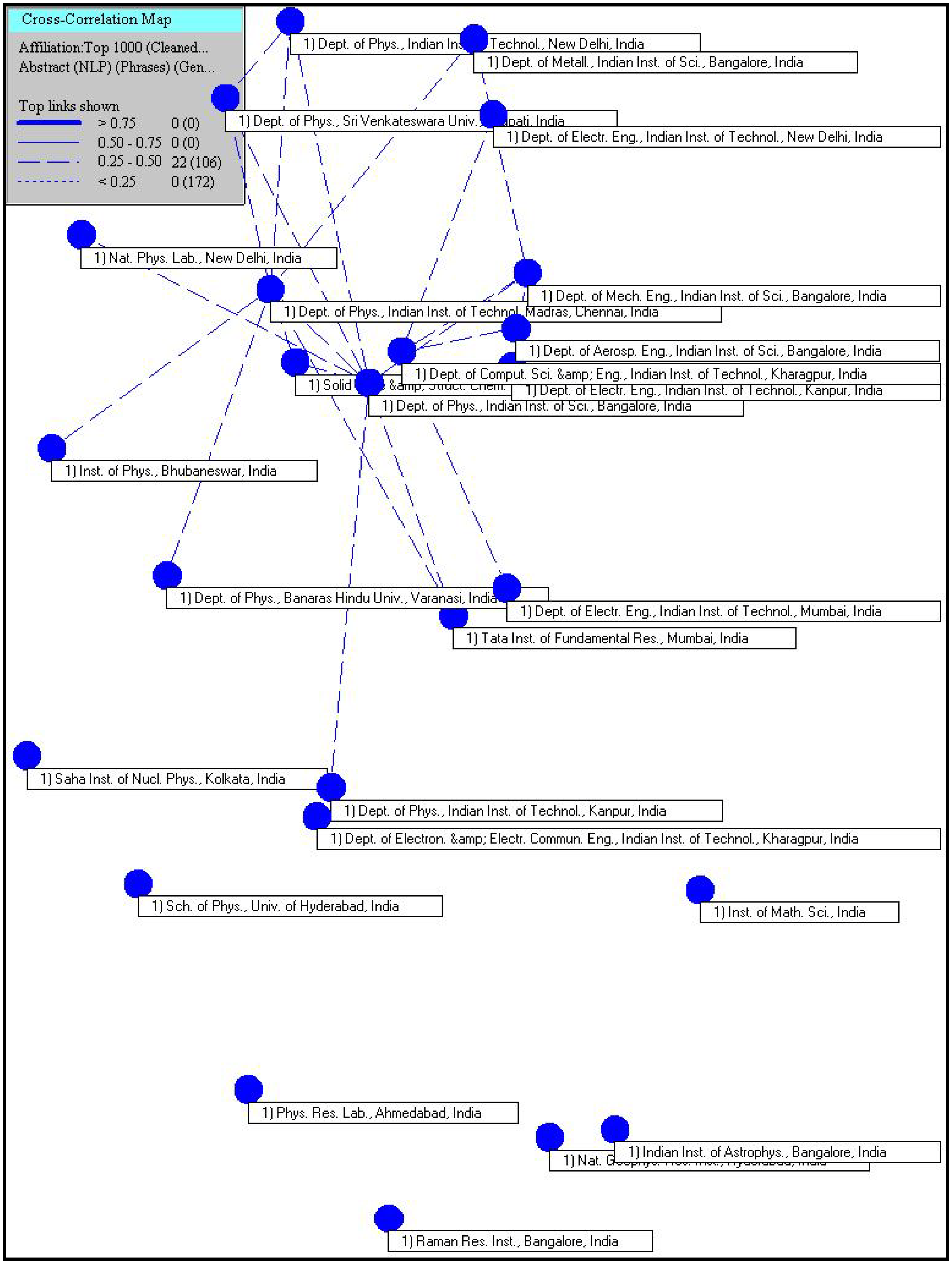

Figure 52. INSPEC Cross-Correlation Map Affiliation x Generic Phrases (NLP)

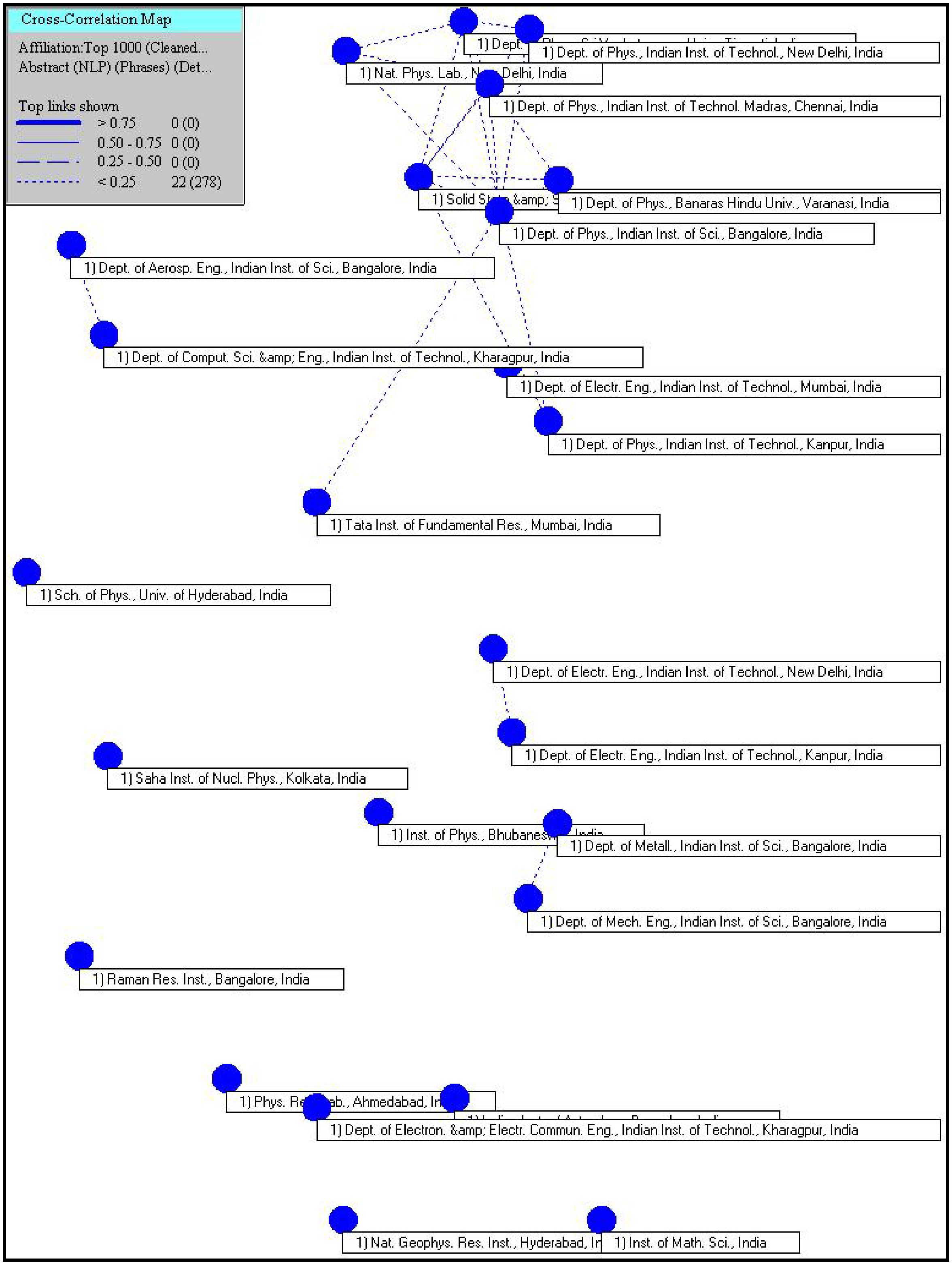

Figure 53. INSPEC Cross-Correlation Map Affiliation x Detailed Phrases (NLP)

3.3.7 Affiliation-Journal Co-Occurrence

Finally, to identify preferred affiliations publishing venues, affiliation – journal co-occurrence matrices were generated as shown in Tables 15 through 17, for the SCI/SSCI, EC and INSPEC 2005-2006 databases, respectively. The Top 25 major journals for the Top 25 affiliations are listed along with the number of records published within a given journal. Journal Impact Factors are also listed and Indian journals are highlighted. The thrusts of each affiliation can be seen from analysis of the leading journals in which its research is published. For example, the Indian Institute of Technology (IIT) covers a broad range of physics, chemistry, and materials, with an emphasis on physics, mainly applied. The Indian Institute of Science emphasizes the more fundamental aspects of physics, materials, and chemistry. Bhabha Atomic Research Center emphasizes physics strongly, with some chemistry as well; and the University of Delhi emphasizes spectroscopy and physics. In addition, the journals in which the Top 25 affiliations publish tend to be the more well-known higher Impact Factor journals (with some exceptions), as opposed to the low Impact Factor high frequency journals identified during the overall India publication analysis. This provides further evidence of the deficiencies in drawing conclusions about a country's S&T enterprise based on aggregate country bibliometrics, and suggests strongly that affiliation and technical discipline stratifications are important in determining quality of publication venues.

Basic analysis of co-occurrence statistics indicates that the total number of total records published by the Top 25 affiliations (column B) equaled 22,627; and that the total number of records published in the Top 25 journals equaled 9,051 (for the SCI/SSCI 2005-2006 database). The total number of records published by the Top 25 affiliations in the Top 25 journals equaled 3,176, or approximately 14% of the total 22,627 records. In addition, the total number of records published by the Top 25 affiliations (3,176) accounts for approximately 35% of the total number of records published in the Top 25 journals (9,051). For the Top 25 journals (median journal impact factor equal to 1.12), 13 are Indian journals (highlighted) and 12 are international journals. The total number of records published in Indian Journals (median impact factor equal to 0.31) equaled 872, or approximately, 27% of the total records published by the Top 25 affiliations (3,176) in the Top 25 journals. The total number of records published in non-Indian Journals (median impact factor equal to 2.01) equaled 2,304, or approximately, 73% of the total records published by the Top 25 affiliations in the Top 25 journals.

Basic analysis of co-occurrence statistics indicates that the total number of total records published by the Top 25 affiliations (column B) equaled 1,365; and that the total number of records published in the Top 25 journals equaled 4,990 (for the EC 2005-2006 database). The total number of records published by the Top 25 affiliations in the Top 25 journals equaled 355, or approximately 26% of the total 1,365 records. In addition, the total number of records published by the Top 25 affiliations (355) accounts for approximately 7% of the total number of records published in the Top 25 journals (4,990). For the Top 25 journals (median journal impact factor equal to 1.712), two are Indian journals (highlighted) and 23 are international journals. The total number of records published in Indian Journals (median impact factor equal to 0.252) equaled 31, or approximately, 0.09% of the total records published by the Top 25 affiliations (355) in the Top 25 journals. The total number of records published in non-Indian

Journals (median impact factor equal to 1.84) equaled 324, or approximately, 91% of the total records published by the Top 25 affiliations in the Top 25 journals.

Basic analysis of co-occurrence statistics indicates that the total number of total records published by the Top 25 affiliations (column B) equaled 1,924; and that the total number of records published in the Top 25 journals equaled 4,203 (for the INSPEC 2005-2006 database). The total number of records published by the Top 25 affiliations in the Top 25 journals equaled 450, or approximately 23% of the total 1,924 records. In addition, the total number of records published by the Top 25 affiliations (450) accounts for approximately 11% of the total number of records published in the Top 25 journals (4,203). For the Top 25 journals (median journal impact factor equal to 1.62), six are Indian journals (highlighted) and 19 are international journals. The total number of records published in Indian Journals (median impact factor equal to 0.379) equaled 108, or approximately, 24% of the total records published by the Top 25 affiliations (450) in the Top 25 journals. The total number of records published in non-Indian Journals (median impact factor equal to 2.02) equaled 342, or approximately, 76% of the total records published by the Top 25 affiliations in the Top 25 journals.

TABLE 15. SCI/SSCI AFFILIATION - JOURNAL CO-OCCURRENCE MATRIX (2005 - 2006)

SCI/SSCI Co-occurrence Matrix - Top 25 Affiliations x Top 25 Journals (2005 - 2006)

		Affiliations (Name):Top 25 (Cleaned)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		# Records	774	747	602	574	547	482	472	428	412	406	377	331	286	255	253	248	237	209	208	207	204	202	197	197	196
		Journal Impact Factors	0.728	0.052	0.090	2.477	0.581	0.153	0.340	1.072	0.446	0.084	0.123	3.185	0.072	0.632	0.495	0.380	2.498	1.290	4.852	0.312	4.033	0.860	0.217	2.348	0.777
Journals	# Records		Curr. Sci	Indian Vet. J	Indian J. Anim. Sci	Tetrahedron Lett	Acta Crystallogr. Sect. E	Asian J. Chem	J. Indian Chem. Soc	J. Appl. Polym. Sci	Indian J. Chem. Sect B	Indian J. Agric. Sci	J. Food Sci. Technol	Phys. Rev. B	Indian J. Phys	Indian J. Chem. Sect A	Indian J. Pure Appl. Phys	Pramana-J. Phys	J. Appl. Phys	Spectroc. Acta Pt. A	Phys. Rev. D	Indian J. Heterocycl. Chem	J. Phys. Chem. B	Synth. Commun	J. Geol. Soc. India	J. Mol. Catal. A-Chem	Bull. Mat. Sci
1	6111	Indian Inst Technol	45			72	16	3	1	68	4		9	50	10	19	9	39	69	8	10		38	5	14	15	22
2	2151	Indian Inst Sci	38	1		24	63			16	8			62	2	6	1	20	18	1	5		41	2	3	1	11
3	1295	Bhabha Atom Res Ctr	14			9	5		2	4			7	27	4	4	8	21	12	7	5		19	2	1	1	7
4	964	Univ Delhi	15		2	7		2	21		10		1	1	2	12	5	13	10	27	22			7	1		
5	939	Indian Inst Chem Technol	2			144	112	1	2	23	18					2						2	10	30		51	1
6	860	Jadavpur Univ	4			7	2	4	13	1	5		5	1	11	10	2	4	8	4	4		6	3	2		2
7	843	Tata Inst Fundamental Res	9			1				1			1	40			1	20	24		55		1				1
8	777	All India Inst Med Sci	1							1										1							
9	773	Natl Chem Lab	6			45	5	1	5	15	8			4		4		1	3				14	8		37	9
10	747	Banaras Hindu Univ	13			1	2	1	9		10	6		7	3	1	3	4	3	10	3	1	2	3	5		8
11	678	Univ Madras	9			21	96		1	1	3				4	2		3	1				1	8	4	6	1
12	607	Anna Univ	9				51			10	1					1	3	1		1			1		2	13	2
13	591	Indian Assoc Cultivat Sci	4			19	3		8	5	4			14	4	9		4	22	4	3		22	1		3	1
14	510	Panjab Univ	2			1	15	7	2		3			1			3	1			36		1	2	3		
15	507	Aligarh Muslim Univ	3					2	7	1	4					10	2	3	5	3	2				5	1	
16	483	CSIR	6			18	1			10	2							1	2				6	3		5	1
17	471	Univ Hyderabad	5			13	5				2			3		2	1	5	3	1	1		3		1		2
18	465	Indian Stat Inst										2									1						
19	445	Univ Calcutta	3			3	4		15	7	5	2	2	4	3	1	2	2	4	3	3			1	3		5
20	438	Univ Mysore	7			1	109		2	11	5		3		2		3	1				4		3	4		3
21	436	Postgrad Inst Med Educ & Res																									
22	429	Natl Inst Technol	1			1	8	1	7	3	9				1	1	4	1	1			3		1			3
23	380	Saha Inst Nucl Phys	1											29	2	3		11	6	4	24		3			1	
24	375	Annamalai Univ	6				8	3	1		3				9	5	8	1		12		1		1		2	
25	352	Cent Drug Res Inst	1			43	3				4					2				1		2		5		1	

TABLE 16. EC AFFILIATION – JOURNAL CO-OCCURRENCE MATRIX (2005 - 2006)

EC Co-occurrence Matrix - Top 25 Affiliations x Top 25 Journals (2005 - 2006)																											
		Affiliations Top 25 (Cleaned)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		# Records	408	400	296	288	266	234	233	207	206	189	178	173	171	164	159	154	150	146	145	144	139	137	135	135	133
		Journal Impact Factor	0.402	1.072	NA	0.38	0.123	1.29	2.498	0.777	4.033	2.348	0.901	1.347	3.138	2.438	1.299	1.504	0.796	2.145	1.544	2.023	1.136	4.127	1.863	2.418	1.489
Journal	# Records		Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial	Journal of Applied Polymer Science	Proceedings of SPIE - The International Society for Optical Engineering	Pramana - Journal of Physics	Journal of Food Science and Technology	Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy	Journal of Applied Physics	Bulletin of Materials Science	Journal of Physical Chemistry B	Journal of Molecular Catalysis A: Chemical	Journal of Materials Science	Materials Science and Engineering A	Journal of Chemical Physics	Chemical Physics Letters	Materials Letters	Industrial and Engineering Chemistry Research	Physica B: Condensed Matter	Journal of Physics Condensed Matter	Journal of Hazardous Materials	Journal of Colloid and Interface Science	Materials Chemistry and Physics	Applied Physics Letters	Bioresource Technology	Physical Review E - Statistical, Nonlinear, and Soft Matter Physics	Solid State Communications
1	142	Department of Aerospace Engineering, Indian Institute of Science, Bangalore			1				4		1		1	6						2				4		2	
2	131	Department of Chemical Engineering, Indian Institute of Science, Bangalore			2						3				9			9				2				3	
3	82	Solid State and Structural Chemistry Unit, Indian Institute of Science, Bangalore				3			1	3	13				6					2				1		4	1
4	66	Central Electrochemical Research Institute, Karaikudi		2		1				1			1					3					6				
5	60	National Physical Laboratory, New Delhi			1	1		1	7	1			2				1			1				5			3
6	59	Tata Institute of Fundamental Research, Mumbai				3			6						1	1			3	1				4		1	
7	59	Institute of Physics, Bhubaneswar 751 005, India				7			5	2										2				1		3	
8	56	School of Chemistry, University of Hyderabad, Hyderabad				1					3				6												
9	56	Department of Chemistry, Indian Institute of Technology Roorkee, Roorkee						2				2						1				6					
10	55	Physical and Materials Chemistry Division, National Chemical Laboratory, Pune							3		1						15					1	5	2			1
11	51	Materials Science Centre, Indian Institute of Technology, Kharagpur		6									1	1									1				1
12	49	National Metallurgical Laboratory, Jamshedpur 831007, India				1			1				2	5			3										
13	48	Electrical Engineering Department, Indian Institute of Technology Delhi, New Delhi							7																		
14	44	Department of Physics and Astrophysics, University of Delhi, Delhi				7			3											1			1			2	
15	43	National Institute of Oceanography, Dona Paula, Goa			9																						
16	42	Department of Materials Science, Indian Association for the Cultivation of Science, Jadavpur, Kolkata		1		1			2			2		2	1		2	2		1			2				1
17	41	Department of Chemistry, Indian Institute of Technology, Kanpur		5		3																2			1		
18	39	Department of Physics, Sri Venkateswara University, Tirupati						7	1								2		5	2			1				
19	39	Department of Computer Science and Automation, Indian Institute of Science, Bangalore	12																								
20	37	Physical Research Laboratory, Navrangpura, Ahmedabad				2									3					1						4	
21	34	School of Chemical Sciences, Mahatma Gandhi University,Kerala		6									2														
22	33	Department of Physics, Banaras Hindu University, Varanasi				1		2			1			2	1											2	
23	33	Chemical Laboratory, Central Leather Research Institute,Chennai									2				1												
24	33	Department of Electrical Engineering, Indian Institute of Technology Delhi, New Delhi	2																								
25	33	Crystal Growth Centre, Anna University, Chennai								1							1							1			1

TABLE 17. INSPEC AFFILIATION - JOURNAL CO-OCCURRENCE MATRIX (2005 - 2006)

INSPEC Co-occurrence Matrix - Top 25 Affiliations x Top 25 Journals (2005 - 2006)

Journal	# Records	Affiliation:Top 25 (Cleaned)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		# Records	297	264	241	236	212	203	197	196	180	166	166	165	147	145	144	143	141	130	127	122	121	119	118	114	109
		Journal Impact Factors	0.728	0.38	0.495	3.185	0.232	0.232	1.072	2.498	0.777	1.299	1.347	0.901	1.181	0.796	2.438	2.145	0.215	4.033	3.138	1.136	4.127	1.489	0.226	4.852	1.681
			Current Science	Pramana, Journal of Physics	Indian Journal of Pure and Applied Physics	Physical Review B	Spectrochimica Acta, Part A	Journal of Scientific and Industrial Research	Journal of Applied Polymer Science	Journal of Applied Physics	Bulletin of Materials Science	Materials Letters	Materials Science & Engineering A	Journal of Materials Science	Nuclear Instruments & Methods in Physics Research, Section B	Physica B	Chemical Physics Letters	Journal of Physics: Condensed Matter	Transactions of the Indian Institute of Metals	Journal of Physical Chemistry B	Journal of Chemical Physics	Materials Chemistry and Physics	Applied Physics Letters	Solid State Communications	Indian Journal of Chemical Technology	Physical Review D	Journal of Crystal Growth
1	166	Dept. of Phys., Indian Inst. of Sci., Bangalore, India		6		17				9	1					1	1	4			5		5	1			2
2	128	Dept. of Comput. Sci. & Eng., Indian Inst. of Technol., Kharagpur, India								1			1										1				
3	101	Tata Inst. of Fundamental Res., Mumbai, India		2		7				5					1	6		1					3	3		3	
4	100	Dept. of Electr. Eng., Indian Inst. of Technol., New Delhi, India																									
5	84	Dept. of Electr. Eng., Indian Inst. of Technol., Kanpur, India																									
6	82	Raman Res. Inst., Bangalore, India	4	3		1												1					1	1		6	
7	77	Dept. of Aerosp. Eng., Indian Inst. of Sci., Bangalore, India																									
8	76	Solid State & Struct. Chem. Unit, Indian Inst. of Sci., Bangalore, India	1	2		7				1	4	1					2	1		13	4		1	1			1
9	72	Phys. Res. Lab., Ahmedabad, India	9	2																	2					1	
10	71	Nat. Phys. Lab., New Delhi, India		1	1	1	1	4		6	1			1	1			1					6	2			
11	71	Dept. of Mech. Eng., Indian Inst. of Sci., Bangalore, India				1							3	1						1							
12	69	Dept. of Electron. & Electr. Commun. Eng., Indian Inst. of Technol., Kharagpur, India								1																	
13	68	Indian Inst. of Astrophys., Bangalore, India		2																	1						
14	68	Nat. Geophys. Res. Inst., Hyderabad, India	34		2						1																
15	67	Inst. of Phys., Bhubaneswar, India		1		2				4					14	2		2					1			2	
16	66	Saha Inst. of Nucl. Phys., Kolkata, India		3		4				1					4	1	1	1		1			1	1		3	
17	65	Dept. of Phys., Indian Inst. of Technol., Kanpur, India		9		7	1			5						1	1	3			1		3				
18	65	Dept. of Electr. Eng., Indian Inst. of Technol., Mumbai, India																									
19	64	Dept. of Phys., Indian Inst. of Technol., New Delhi, India		1		2					1						1					2	1	1			
20	64	Sch. of Phys., Univ. of Hyderabad, India	2	4	1	3				1	1			1	5	1	1	4		1			1	2		1	
21	64	Dept. of Phys., Banaras Hindu Univ., Varanasi, India	2	1	1		5						2		3		1		2		1						
22	62	Dept. of Phys., Sri Venkateswara Univ., Tirupati, India					7		1	2		2		1		9		4				6					
23	60	Dept. of Phys., Indian Inst. of Technol. Madras, Chennai, India				1				9						3		2			1		2	1			
24	58	Dept. of Metall., Indian Inst. of Sci., Bangalore, India							6		1		7						5								
25	56	Inst. of Math. Sci., India		3																						12	

3.4 Collaborative Countries

In the preceding study, the SCI/SSCI database was accessed in March 2006 to identify the main collaborating countries with India on research articles, for the period 2004-2005. For comparative purposes, this study provides updated journal citation report (JCR) data for the period 2005-2006. The results for both periods are provided in Table 18, where the format is as follows:

- Column 1: Country Name listed in descending order of total retrieved records.
- Columns 2 & 4: Number of records (articles) that contained at least one collaborative country author and one India author for the given time period.
- Columns 3 & 5: Total number of citations for the articles listed in Columns 2 & 4 for the given time period.
- Column 6: Average Cites per Record (2004 - 2006).
- Column 7: Average Cites Per Year equal to the total sum of citations for the individual years (2004, 2005, 2006) divided by 3 (years).

TABLE 18. SCI/SSCI MAIN COLLABORATING COUNTRY COMPARISON

Country	Records 2004-2005	Times Cited 2004-2005	Records 2005-2006	Times Cited 2005-2006	Average Cites Per Record	Average Cites Per Year
USA	3,182	5,824	3,608	13,158	3.81	4,667
Germany	1,439	2,928	1,534	6,449	4.45	2,298
Japan	1,046	2,419	1,206	5,179	4.59	1,850
England	877	2,024	1,034	4,647	4.91	1,652
France	712	1,901	852	4,515	5.99	1,598
South Korea	552	1,439	689	3,095	5.14	1,104
China	521	1,891	586	3,987	7.40	1,420
Canada	435	521	526	1,486	3.54	514
Italy	422	1,013	451	2,158	5.15	790
Australia	384	1,396	442	2,430	5.96	899
Russia	316	1,833	349	3,412	10.88	1,242
Spain	268	586	292	1,307	5.22	466
India (only)	46,251	NA > 10,000	52,047	NA > 10,000	NA > 10,000	NA > 10,000

Table 18 indicates that all collaborative countries account for approximately 22% of the total records published for both given periods, with USA as the predominant collaborator (total records = 6,790 or approximately 31% of the total records for all collaborative countries). Table 18 also indicates that although the USA is the predominant collaborator, in terms of both total records and average cites per years (Column 7), the average cites per record (3.81) is significantly less than for other collaborative countries, such as Russia (10.88), Peoples Republic of China (7.4), France (5.99) and Australia (5.96). As previously mentioned, text mining studies of explicit or single technologies over recent years have shown dramatic growth in research output production specifically by the Peoples Republic of China and South Korea that includes both bilateral and multilateral collaboration with India. The results of gross bibliometric analyses for both collaborative countries for the 2005-2006 time period was provided above in Section 3.1.1.3 with details on author affiliations, source journals, subject categories, and controlled vocabulary for SCI/SSCI, EC and INSPEC databases.

To determine the main technical areas of collaboration, it was decided to eliminate massive multi-country studies that tend to include authors from many countries, and focus on articles that had only (India and USA) and (India and Peoples R China) authors. Articles that were published during the 2004-2006 period were downloaded from the SCI/ SSCI database using the two following respective queries (in the address field):

1. *India and USA not (Peoples R China or Japan or Germany or (England Not New England) or Canada or Italy or France or Australia or South Korea or Russia or Spain)*

2. *India and Peoples R China not (USA or Japan or Germany or (England Not New England) or Canada or Italy or France or Australia or South Korea or Russia or Spain)*

The (India and USA) author address query retrieved 3,821 articles, and Table 19 provides the gross bibliometric data for the Top 25 Sources (journals), Author affiliations, and Subject categories. The data listed indicates the following:

Top 25 Sources (journals):

- Total articles published in the Top 25 journals =590
- The average Top 25 Journal impact factor (IF) = 3.159
- The average Top 10 Journal impact factor (IF) = 3.315
- Two of the Top 25 journals are Indian journals (gray highlight).
  - Current Science
  - Pramana - Journal of Physics
- The total citations for the 3,821 total articles = 7,687.
- The median citations* of the Top 10 cited articles retrieved = 92
- The median citations* of the Top 5% of articles retrieved = 15
- The median citations* of the Top 1% of articles retrieved = 36
- The average cites per article = 2.6

* Median citations are provided by SCI/SSCI Citation Reports for 2004-2007.

Top 25 Author Affiliations:

- 2,438 total articles are attributed to the Top 25 affiliations. Note that SCI/SSCI records contain multiple values for author affiliation fields.
- 9 of the Top 25 affiliations are Indian affiliations (India address).
  - Indian Institute of Technology
  - Indian Institute of Science
  - Tata Institute of Fundamental Research
  - University of Delhi

- All India Institute of Medical Sciences
- Bhabha Atomic Research Center
- University of Madras
- Indian Statistical Institute and
- Jawaharlal Nehru University

- 1,126 (46%) total articles are attributed to the Top 9 Indian affiliations.

Top 25 Subject Categories:

- 2,855 total articles are classified in the Top 25 subject categories.
- Chemistry, Biology, Materials Science, Electrical and Electronic Engineering, and Physics are the predominant generalized subject categories.
- Crystallography, Plant Sciences, and Infectious Diseases have been identified as select thrust areas for additional analysis as described below in Section 4 (Taxonomies – Document Clustering).

TABLE 19. SCI/SSCI INDIA AND USA COLLABORATION BIBLIOMETRICS

SCI/SSCI (2004 - 2006) India - USA Collaboration Bibliometrics (Total Records = 3,821)						
Top 25 Source Titles:	**Records**	**Impact Factor (IF)**	**Top 25 Affiliations:**	**Records**	**Top 25 Subject Categories:**	**Records**
PHYSICAL REVIEW B	53	3.185	INDIAN INST TECHNOL	573	BIOCHEMISTRY & MOLECULAR BIOLOGY	253
ASTROPHYSICAL JOURNAL	41	6.308	INDIAN INST SCI	271	MATERIALS SCIENCE, MULTIDISCIPLINARY	234
PHYSICAL REVIEW D	36	4.852	TATA INST FUNDAMENTAL RES	156	ENGINEERING, ELECTRICAL & ELECTRONIC	186
ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	35	0.581	UNIV TEXAS	126	CHEMISTRY, PHYSICAL	168
CURRENT SCIENCE	34	0.728	UNIV DELHI	109	ASTRONOMY & ASTROPHYSICS	138
PHYSICAL REVIEW LETTERS	32	7.489	JOHNS HOPKINS UNIV	101	PHYSICS, APPLIED	131
PHYSICAL REVIEW E	26	2.418	ALL INDIA INST MED SCI	80	PHYSICS, CONDENSED MATTER	131
JOURNAL OF CHEMICAL PHYSICS	24	3.138	UNIV ILLINOIS	78	PHYSICS, MULTIDISCIPLINARY	124
JOURNAL OF APPLIED PHYSICS	23	2.498	UNIV MARYLAND	77	CHEMISTRY, INORGANIC & NUCLEAR	122
POLYHEDRON	23	1.957	HOWARD UNIV	65	PHARMACOLOGY & PHARMACY	114
JOURNAL OF ORGANOMETALLIC CHEMISTRY	22	2.025	PENN STATE UNIV	61	COMPUTER SCIENCE, THEORY & METHODS	112
PRAMANA - JOURNAL OF PHYSICS	22	0.38	HARVARD UNIV	57	CHEMISTRY, ORGANIC	110
APPLIED PHYSICS LETTERS	21	4.127	LOUISIANA STATE UNIV	57	CHEMISTRY, MULTIDISCIPLINARY	94
JOURNAL OF PHYSICAL CHEMISTRY B	20	4.033	UNIV MASSACHUSETTS	57	CRYSTALLOGRAPHY	92
MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS	18	1.347	UNIV MINNESOTA	56	ENVIRONMENTAL SCIENCES	87
GEOPHYSICAL RESEARCH LETTERS	17	2.491	OHIO STATE UNIV	55	PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH	83
METALLURGICAL AND MATERIALS TRANSACTIONS A-PHYSICAL METALLURGY AND MATERIALS SCIENCE	17	1.232	BHABHA ATOM RES CTR	54	PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	80
BIOCHEMICAL AND BIOPHYSICAL RESEARCH COMMUNICATIONS	16	3	UNIV MADRAS	54	PLANT SCIENCES	80
INORGANIC CHEMISTRY	16	3.851	PURDUE UNIV	52	GEOSCIENCES, MULTIDISCIPLINARY	79
JOURNAL OF HIGH ENERGY PHYSICS	16	5.944	UNIV CALIF BERKELEY	52	INFECTIOUS DISEASES	79
JOURNAL OF PHYSICS-CONDENSED MATTER	16	2.145	INDIAN STAT INST	50	PHYSICS, PARTICLES & FIELDS	77
MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	16	5.352	JAWAHARLAL NEHRU UNIV	50	IMMUNOLOGY	74
PHYSICAL REVIEW C	16	3.61	UNIV PITTSBURGH	50	MULTIDISCIPLINARY SCIENCES	71
TETRAHEDRON LETTERS	16	2.477	UNIV MISSOURI	49	BIOPHYSICS	68
BIOCHEMISTRY	14	3.8	MIT	48	BIOTECHNOLOGY & APPLIED MICROBIOLOGY	68
RECORD SUM	**590**	**AVG. IF = 3.159 AVG. IF (Top 10) = 3.315**	**RECORD SUM**	**2438**	**RECORD SUM**	**2855**

Table 9 provided above in Section 3.1.2 (Most Cited Journals) previously indicated that the impact factors for the Top 50 most cited journals (SCI/SSCI 2005-2006) by Indian authors are an order of magnitude higher than the impact factors of journals that contain the most India research articles. Thus, ***Indian authors are citing the high impact factors journals extensively, but not publishing in them extensively***. Table 9 also provided the distribution of most cited Indian journals relative to all cited journals, indicating the most cited Indian only account for a small fraction of the total journal citations for the given SCI/SSCI 2005–2006 dataset. Table 19 provides further evidence that the collaborative research performed by Indian and USA authors is being published in high impact factors journals (average Top 25 Journal impact factor (IF) = 3.159). Table 19 also indicates that the collaborative research is not being published in Indian journals. Only two of the Top 25 journals are India journals with relatively low impact factors.

The (India and Peoples R China) author address query retrieved 295 articles, and Table 20 provides the gross bibliometric data for the Top 25 Sources (journals), Author affiliations, and Subject categories. The data listed indicates the following:

Top 25 Sources (journals):

- Total articles were published in the Top 25 journals = 72
- The average Top 25 Journal impact factor (IF) = 1.716
- The average Top 10 Journal impact factor (IF) = 1.688
- Two of the Top 25 journals are Indian journals (gray highlight).
  - Current Science
  - Indian Journal of Pure & Applied Physics
- The total citations for the 295 total articles = 349.
- The median citations* of the Top 10 cited articles retrieved = 14
- The median citations* of the Top 5% of articles retrieved = 12
- The median citations* of the Top 1% of articles retrieved = 19
- The average cites per article = 1.51

* Median citations are provided by SCI/SSCI Citation Reports for 2004-2007.

Top 25 Author Affiliations:

- 321 total articles are attributed to the Top 25 author affiliations. Note that SCI/SSCI records contain multiple values for author affiliation fields.
- 11 of the Top 25 affiliations are Indian affiliations (India address).
- 106 (33%) total articles are attributed to the Top11 Indian affiliations.

Top 25 Subject Categories:

- 299 total articles are classified in the Top 25 subject categories.
- Physics, Materials Science, Electrical and Electronic Engineering, Mathematics, and Chemistry, Operations and Production research are the predominant generalized subject categories.
- Plant Sciences has been identified as select thrust areas for additional analysis as described below under Section 4 (Taxonomies – Document Clustering).

Table 20 provides further evidence that the collaborative research performed by Indian and Chinese authors is being published in relatively high impact factors journals (average Top 25 Journal impact factor (IF) = 1.716). Table 20 also indicates that the collaborative research is not being published in Indian journals. Only two of the Top 25 journals are India journals with relatively low impact factors. It should be noted that this country collaboration analysis (based on the Boolean queries above) couldn't be extended to include the EC and INSPEC databases since these records contain only one value for the author address field.

TABLE 20. SCI/SSCI INDIA AND PEOPLES REPUBLIC OF CHINA COLLABORATION BIBLIOMETRICS

SCI/SSCI (2004 - 2006) India - China Collaboration Bibliometrics (Total Records = 295)						
Top 25 Source Titles:	**Records**	**Impact Factor (IF)**	**Top 25 Affiliations:**	**Records**	**Top 25 Subject Categories:**	**Records**
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	7	0.481	CHINESE ACAD SCI	57	PHYSICS, MULTIDISCIPLINARY	22
PHYSICAL REVIEW D	5	4.852	INDIAN INST TECHNOL	34	MATERIALS SCIENCE, MULTIDISCIPLINARY	20
ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	4	0.581	UNIV HONG KONG	25	OPERATIONS RESEARCH & MANAGEMENT SCIENCE	19
ACTA PHYSICA SINICA	4	1.051	CITY UNIV HONG KONG	23	PHYSICS, APPLIED	19
CURRENT SCIENCE	4	0.728	HONG KONG POLYTECH UNIV	23	ENGINEERING, ELECTRICAL & ELECTRONIC	18
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH	4	0.824	CHINESE UNIV HONG KONG	15	MATHEMATICS	17
JOURNAL OF APPLIED PHYSICS	4	2.498	ZHEJIANG UNIV	12	MATHEMATICS, APPLIED	16
CHINESE PHYSICS LETTERS	3	1.276	JADAVPUR UNIV	11	PHYSICS, CONDENSED MATTER	16
INORGANIC CHEMISTRY	3	3.851	NANJING UNIV	10	BIOCHEMISTRY & MOLECULAR BIOLOGY	11
INTERNATIONAL JOURNAL OF THERMAL SCIENCES	3	0.738	NANTONG UNIV	10	CHEMISTRY, PHYSICAL	11
JOURNAL OF INTEGRATIVE PLANT BIOLOGY	3	NA	GOVIND BALLABH PANT UNIV AGR & TECHNOL	9	COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	11
ADVANCED FUNCTIONAL MATERIALS	2	6.77	INDIAN STAT INST	9	ENGINEERING, INDUSTRIAL	10
APPLIED MATHEMATICS AND COMPUTATION	2	0.688	BANARAS HINDU UNIV	8	ENGINEERING, MANUFACTURING	10
APPLIED PHYSICS LETTERS	2	4.127	ANNA UNIV	7	PHYSICS, PARTICLES & FIELDS	10
ATMOSPHERIC ENVIRONMENT	2	2.724	HONG KONG BAPTIST UNIV	7	ASTRONOMY & ASTROPHYSICS	9
BIOMETRIKA	2	1	HONG KONG UNIV SCI & TECHNOL	7	ENVIRONMENTAL SCIENCES	9
BIOORGANIC & MEDICINAL CHEMISTRY LETTERS	2	2.478	NATL INST FOUNDRY & FORGE TECHNOL	7	MULTIDISCIPLINARY SCIENCES	9
CEREAL RESEARCH COMMUNICATIONS	2	0.32	XIAMEN UNIV	7	OPTICS	9
CHINESE JOURNAL OF PHYSICS	2	0.44	CTR ADV TECHNOL	6	PLANT SCIENCES	9
CHINESE SCIENCE BULLETIN	2	0.783	INDIAN INST SCI	6	CHEMISTRY, INORGANIC & NUCLEAR	8
CRYPTOGAMIE MYCOLOGIE	2	0.418	SHANGHAI JIAO TONG UNIV	6	COMPUTER SCIENCE, THEORY & METHODS	8
EXPERT SYSTEMS WITH APPLICATIONS	2	1.236	UNIV CALCUTTA	6	ENGINEERING, MECHANICAL	8
FLUORIDE	2	0.569	UNIV SCI & TECHNOL CHINA	6	CHEMISTRY, ORGANIC	7
IEEE PHOTONICS TECHNOLOGY LETTERS	2	2.266	CCAST	5	POLYMER SCIENCE	7
INDIAN JOURNAL OF PURE & APPLIED PHYSICS	2	0.495	GURU GOBIND SINGH INDRAPRASTHA UNIV	5	CHEMISTRY, MULTIDISCIPLINARY	6
RECORD SUM	**72**	**AVG. IF = 1.716 AVG. IF (Top 10) = 1.688**	**RECORD SUM**	**321**	**RECORD SUM**	**299**

To gain a better perspective on overall Indian research article citations and journal impact factors, Journal Citation Reports (JCR Science Edition 2005) were extracted from the SCI/SSCI database for all Indian journals. Table 21 provides a complete listing of the bibliometric results in the following columnar format:

1. Journal Title
2. Rank = order sorted by descending journal impact factor.
3. Impact Factor = Average number of times articles from the journal published in the past two years (2003, 2004) have been cited in the JCR year (2005);
4. Records = Number of articles published in 2005.
5. Total Cites = Number of journal article citations (all years 1975-2005).
6. Immediacy Index = Cites in 2005 to articles published in 2005 ÷ Number of articles published in 2005.
7. Cited Half-life = Median age of articles cited in 2005. Half of the citations to the journal are to articles published within the cited half-life.

Table 21 comprises 49 Indian journals with the average impact factor for all Indian journals equals 0.347. The average total cites for all journals is slightly greater than 500, and the median age of articles cited for the majority of journals is significantly greater than 5 years. As indicated, the journals with highest impact factors are associated with Biosciences, Chemical Sciences, Medical Research, Genetics and Material Sciences.

For additional perspective through comparison, the following data was extracted from the complete JCR Science Edition 2005 (6,088 total Journals) for all countries.

- The maximum Indian journal impact factor equals 1.031 (Journal of Biosciences, published by the Indian Academy of Sciences); and the maximum journal impact factor for all countries equals 49.79 (USA: CA-Cancer Journal for Clinicians).

- The maximum Indian journal total cites equals 3,451 (Current Science, published by the Current Science Association); and the maximum journal total cites for all countries equals 404,397 (USA: Journal of Biological Chemistry).

- The maximum Indian journal Immediacy Index equals 0.476 (Indian Journal of Medical Research, published by the Indian Council of Medical Research); and the maximum journal Immediacy Index for all countries equals 21.3 (USA: CA-Cancer Journal for Clinicians).

TABLE 21. SCI/SSCI INDIA JOURNAL CITATION REPORT BIBLIOMETRICS

SCI/SSCI Indian Journal Citation Reports (JCR Science Edition 2005)						
Abbreviated Journal Title	**Rank**	**Impact Factor**	**Records 2005**	**Total Cites All Years**	**Immediacy Index**	**Cited Half-life**
J BIOSCIENCES	1	1.031	71	489	0.268	5
P INDIAN AS-CHEM SCI	2	0.921	0	386		5.4
INDIAN J MED RES	3	0.869	124	1497	0.476	>10.0
J GENET	4	0.833	30	407	0.1	>10.0
J CHEM SCI	5	0.818	81	42	0.074	
B MATER SCI	6	0.777	117	754	0.026	5.3
CURR SCI INDIA	7	0.728	537	3451	0.294	5.9
J ASTROPHYS ASTRON	8	0.7	26	152	0.269	8.6
ALLELOPATHY J	9	0.686	63	147	0.032	4.1
INDIAN J CHEM A	10	0.632	195	2033	0.103	8.8
NATL MED J INDIA	11	0.614	48	260	0.229	5.2
INDIAN J BIOCHEM BIO	12	0.505	62	550	0.129	>10.0
INDIAN J PURE AP PHY	13	0.495	152	821	0.026	9.2
INDIAN J CHEM B	14	0.446	271	2284	0.055	>10.0
SADHANA-ACAD P ENG S	15	0.395	44	85	0.159	
J POLYM MATER	16	0.393	52	233	0	5.8
NEUROL INDIA	17	0.385	48	367	0.146	4.2
PRAMANA-J PHYS	18	0.38	216	781	0.153	5
J ENVIRON BIOL	19	0.34	119	229	0	5.3
J INDIAN CHEM SOC	20	0.34	257	1922	0.062	>10.0
J PLANT BIOCHEM BIOT	21	0.338	42	103	0.071	5.8
INDIAN J HETEROCY CH	22	0.312	127	287	0.024	5.2
B ELECTROCHEM	23	0.294	76	392	0	6.7
ORIENT INSECTS	24	0.288	32	109	0	>10.0
P INDIAN AS-EARTH	25	0.24	0	194		7.5
J SCI IND RES INDIA	26	0.232	123	453	0.016	8.5
INDIAN J CHEM TECHN	27	0.226	101	288	0.04	6.2
J GEOL SOC INDIA	28	0.217	150	850	0.08	>10.0
T INDIAN I METALS	29	0.215	116	161	0.017	9.4
INDIAN J MAR SCI	30	0.202	44	330	0.114	>10.0
INDIAN J FIBRE TEXT	31	0.19	65	125	0.015	5.6
J CAMEL PRACT RES	32	0.174	15	93	0	
DEFENCE SCI J	33	0.172	44	97	0.023	
INDIAN J ENG MATER S	34	0.16	75	106	0.053	4.9
P INDIAN AS-MATH SCI	35	0.154	43	103	0	6.5
ASIAN J CHEM	36	0.153	467	477	0.066	4.3
J APPL ANIM RES	37	0.132	59	103	0.051	5.4
J FOOD SCI TECH MYS	38	0.123	139	810	0	>10.0
INDIAN J ANIM SCI	39	0.09	312	1051	0.016	>10.0
INDIAN J AGR SCI	40	0.084	153	470	0	>10.0
ASIAN J SPECTROSC	41	0.083		30		
INDIAN J PURE AP MAT	42	0.073	32	252	0	9
INDIAN J PHYS	43	0.072	202	342	0.02	6.9
NATL ACAD SCI LETT	44	0.057	51	64	0	
IETE J RES	45	0.052	52	19	0.019	
INDIAN VET J	46	0.052	438	800	0.009	>10.0
IETE TECH REV	47	0.01	45	29	0	
J ADV ZOOL	48	0		18		
J EARTH SYST SCI	49		75	6	0.067	

The gross bibliometric analysis presented above provided an overall perspective on India collaborative research with the USA and Peoples Republic of China by addressing the effects of collaboration (co-authorship), through use of several country address queries, on output production (total articles published); and regarded research utility (article citations and associated journal impact factors). However, the above analysis did not include other Boolean country address queries of interest using India, USA, and Peoples Republic of China search terms. The analysis did also not completely address the impact or effects of prolific authors and their affiliations, other countries, and highly ranked journals on output production and article citation trends. To determine these effects, the following analysis required retrieval of research articles using each of the Boolean country address queries (refer to Figure 54) over the period (2005-2006), and systematically excluding the Top 10 authors, Top 10 affiliations (institutions), other Top 10 collaborating countries, and Top 10 ranked journals, based on their respective output production. Figure 54 clearly illustrates these effects on total output production for all single and combined Boolean country address queries considered to be of primary interest.

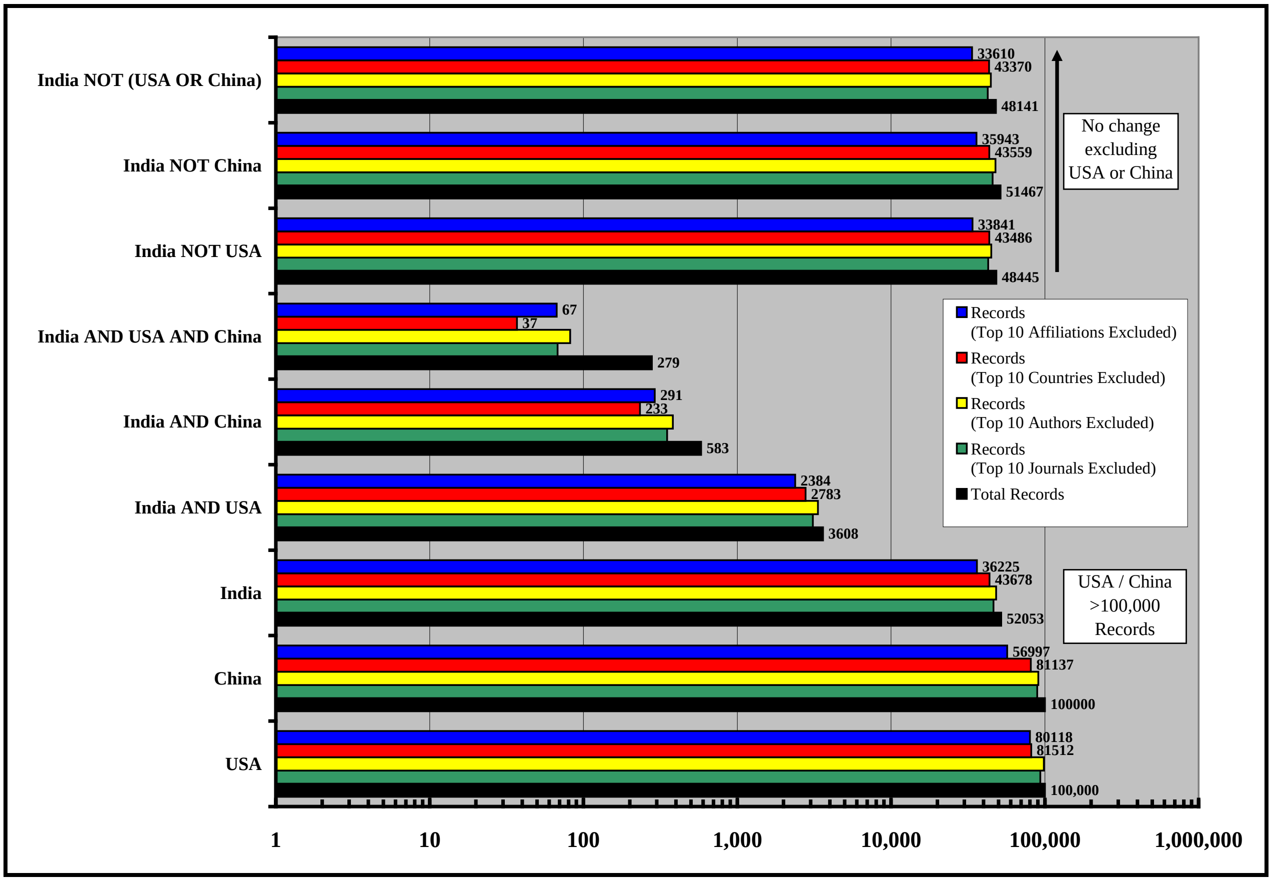

Figure 54. Effects of Prolific Authors, Affiliations, Countries, and Ranked Journals on India Research Output Production

Figure 54 illustrates several important factors worth noting:

- *The actual total output retrieved for the USA and China address queries exceeded 100,000 articles.*

- *There is a significant decrease in total output for all three multiple address queries that combine India, USA and/or China using the Boolean "AND" operator. This indicates that the overall output production for India is not affected by the percentage of USA or China contributions.*

- *The total output for the two multiple address queries using "AND China" search terms decreases significantly when the Top 10 affiliations and other collaborating countries are excluded. This effect is more dramatic when compared to the multiple address "India AND USA" query.*

- *The outputs for the three Boolean "NOT" queries are not affected exclusion of Top 10 authors, institutions, other collaborating countries, or ranked journals.*

- *The outputs for the three Boolean "NOT" queries are essentially identical to the India address (ONLY) query, further indicating that the overall output production for India is not affected by the percentage of USA or China contributions (no significant change in output when USA and/or China is excluded).*

Figure 55 illustrates the effects of systematic exclusions of Top 10 authors, affiliations, other collaborating countries, and ranked journals on the median citation of Top 10 highest cited research articles. The median citation for the Top 10 highest cited articles is a select representative indicator of regarded utility, and is calculated as the average of the total cites for the 5^{th} and 6^{th} ranked articles. As shown, there are very significant effects on the median citation for specific country address queries when the Top 10 affiliations (institutions) are excluded. The effects are equally significant when other Top 10 collaborating countries are excluded, indicating suggestive relationships between the collaborative nature and overall utility of India research.

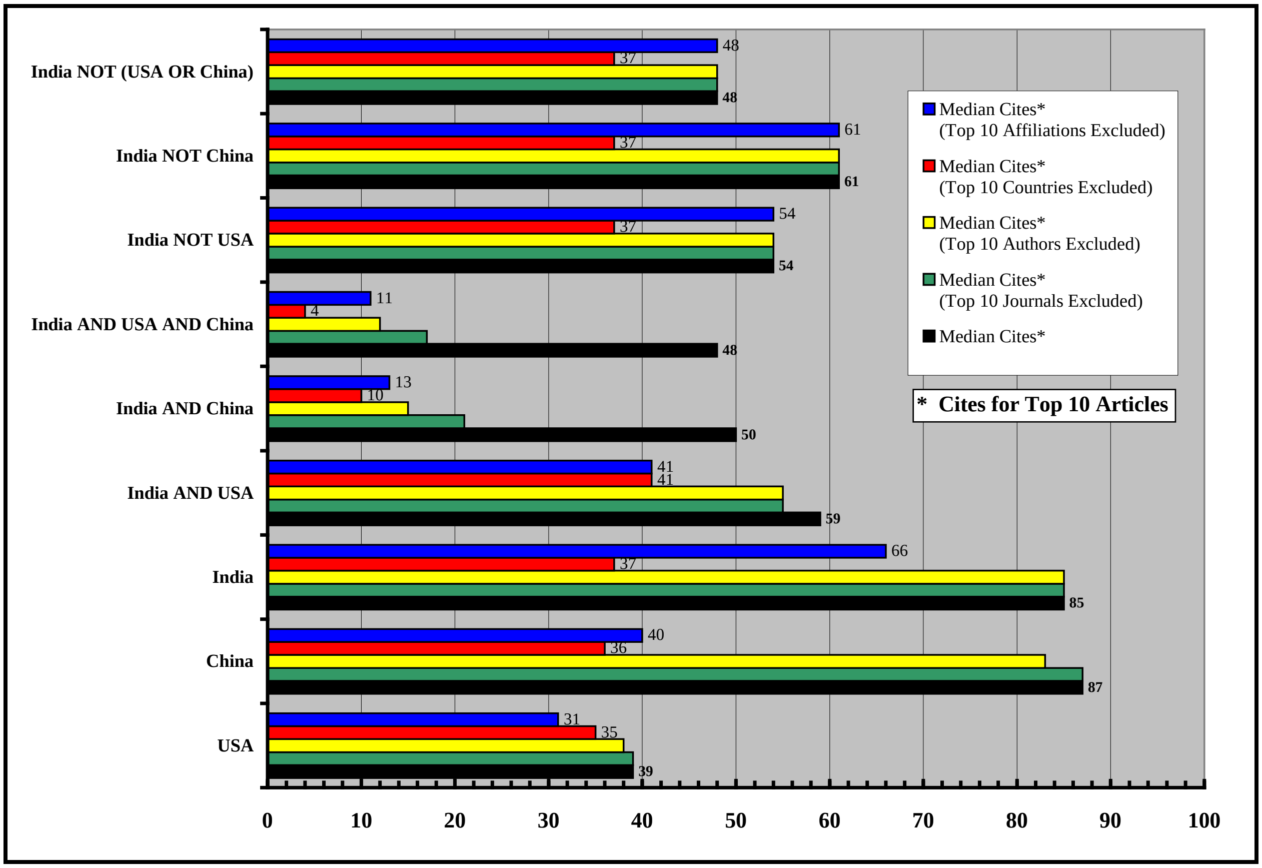

Figure 55. Effects of Prolific Authors, Affiliations, Countries, and Ranked Journals on India Research Article Citations

Figure 55 illustrates several important factors worth noting:

- *The median citations of articles retrieved using the India and China address queries are significantly greater than USA.*
- *A dramatic decrease in median citations of articles occurs however, for India and specially China (> 50%), when Top 10 affiliations (institutions) are excluded. This effect is not as significant for USA.*
- *A dramatic decrease in median citations of articles occurs for both India and China (> 50%), when other Top 10 countries excluded. This effect is also not as significant for USA.*
- *The median citations for the two multiple address queries using "AND China" search terms decreases significantly when all Top 10 entities (including journals and authors) are independently excluded. This effect is more dramatic when compared to the multiple address "India AND USA" query. This suggests that the majority of highly cited research articles containing China country addresses are being published by a narrow, strongly linked group of authors and institutions in select journals with relatively high impact factors.*

- *The median citations for the three Boolean "NOT" queries are reduced in magnitude (≈ 28-54 %) compared to the India address (ONLY) query, however all queries exhibit essentially identical trends. This further indicates that the overall regarded utility of research articles (based on median citations) published by India is not affected by the percentage of USA or China contributions (no significant change in cites when USA and/or China is excluded).*

Since the total outputs and median citations for the two multiple address queries using "AND China" search terms are highly dependent on the exclusion of the Top 10 entities, additional analysis was performed for the Peoples Republic of China to further investigate these effects using select Boolean country address queries. The analysis results as illustrated in Figure 56.

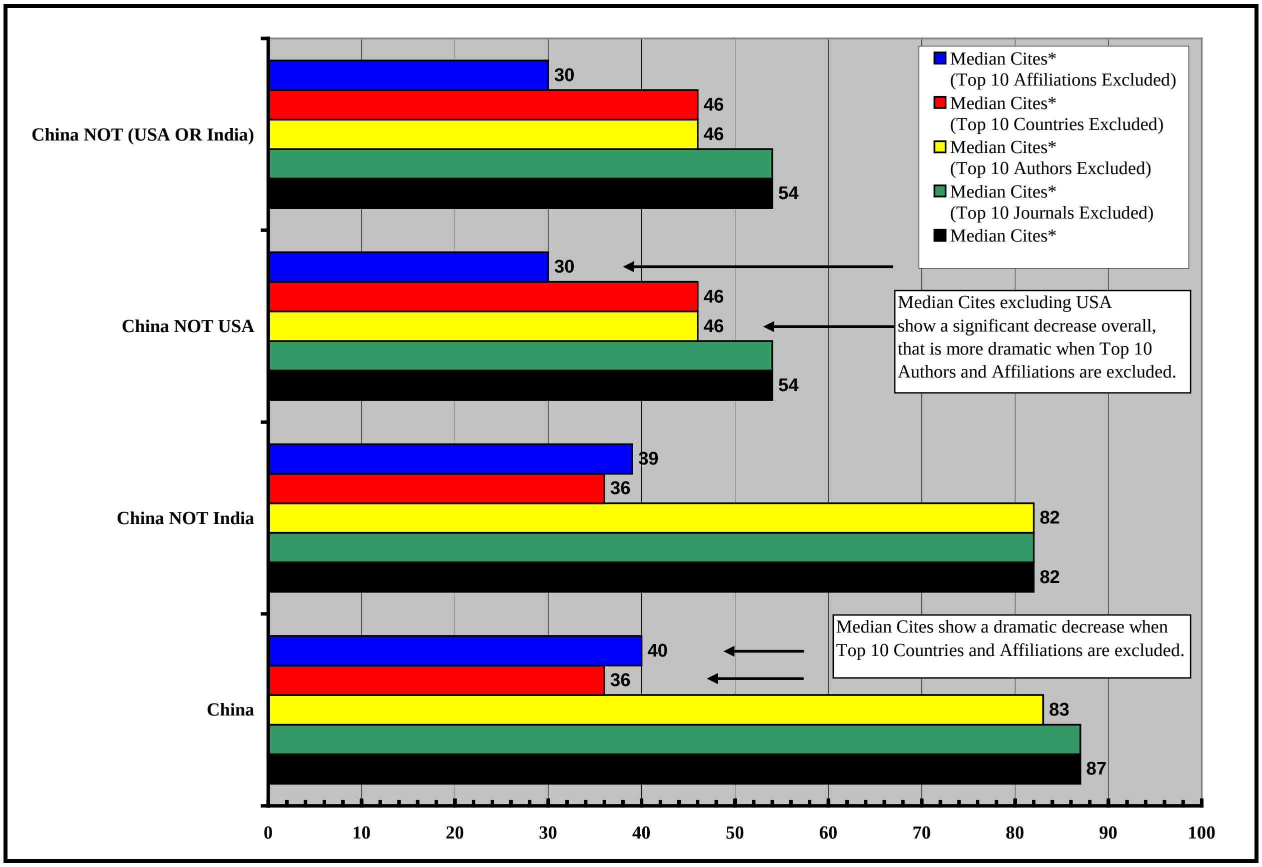

Figure 56. Effects of Prolific Authors, Affiliations, Countries, and Ranked Journals on Peoples Republic of China Research Article Citations

Figure 56 illustrates several important factors worth noting:

- A dramatic decrease in median citations of articles occurs when Top 10 countries and affiliations (institutions) are excluded.
- The exclusion of India (China NOT India) has no effects.

- The exclusion of USA (China NOT USA) results in a significant decrease in median citations that is even more dramatic when Top 10 Authors and Affiliations are excluded. This suggests that *that the overall output and regarded utility of research articles (based on median citations) published by China is affected by USA collaborative efforts that between narrow strongly linked group of authors and institutions.*

The detailed bibliometric analysis presented above was intended to provide an overall perspective on India collaborative research with the USA and Peoples Republic of China by addressing the effects of collaboration on output production (total articles published); and regarded research utility (article citations and associated journal impact factors). The analysis also addressed the impact or effects of prolific authors and their affiliations, other countries, and highly ranked journals on output and article citation trends. The bibliometrics presented above were also intended to provide a framework and keener perspective for an extended India research collaboration analysis involving the USA and Peoples Republic of China by identifying and investigating the pervasive technical themes of India's research.

The following sections provide the results of a computational linguistics (document clustering) analysis that was primarily performed to identify the pervasive technical themes of India's research. Document clustering is the grouping of similar research articles into thematic categories that is depicted in the present study as a hierarchical tree that represents the overall taxonomy of India's research. The clustering analyses were performed using the India author country address (ONLY) query to retrieve research articles from the SCI/SSCI, EC and INSPEC databases over the period (2005-2006).

It should be noted that the extended India research collaboration analysis involving the USA and Peoples Republic of China (refer below to Section 4.1.4) was performed based on the results of the document clustering analysis that identified several predominant single technology focus areas of research in all three databases. Specifically, the levels of emphasis (total number of research articles published) for the following single technology focus areas warranted extended research collaboration analyses.

1. Molecular thin film (organic and inorganic) research primarily focused on semiconductor and photovoltaic applications.
2. Agronomy primarily focused on crop rotation, irrigation and drainage, soil classification, and soil fertility experiments; and Plant Sciences primarily focused on genetics (selective breeding) to improve crop yields.

4 Taxonomies - Document Clustering

This section presents the pervasive technical themes of India's research, the relationships among those themes, and the levels of emphasis (number of research articles published) associated with each of the themes. The general approach that was used required grouping the retrieved raw records into categories of similar research articles, identifying the central themes through phrase analysis of the articles in each category, and tabulating the number of articles associated with each category. Many approaches for grouping these records have been developed and used for general data mining analyses. The analyses presented in the following sections use a document clustering approach, based on favorable results from previous text mining studies. Document clustering is the grouping of similar research articles into thematic categories that is depicted in the present study as a hierarchical tree that represents the overall taxonomy of India's research. Again, many different clustering approaches exist (e.g., Willett, 1988; Rasmussen, 1992; Cutting, 1992; Guha, 1998; Hearst, 1998; Zamir, 1998; Karypis, 1999; Steinbach, 2000); and the approach presented in this section is based on a partitional clustering algorithm (Zhao and Karypis, 2001, 2002) contained within a software package named CLUTO. Most of CLUTO's clustering algorithms treat the clustering problem as an optimization process that seeks to maximize or minimize a particular clustering criterion function defined either globally or locally over the entire clustering solution space. CLUTO uses a randomized incremental optimization algorithm that is greedy in nature, and has low computational requirements. Appendix B describes the partitional clustering approach in more detail. In addition, the novel Spacetree software package was used as a supplemental tool to visualize and browse the hierarchical tree generated by the CLUTO software.

4.1 Document Clustering Results

In partitional clustering, the number of clusters desired is input, and all records or research articles in a dataset are included in those clusters. The number of clusters per level is equals 2^N where N = 0, 1, 2 …, denotes the Level number. The total number of clusters equals the sum of clusters over all Levels. Select clustering was performed for the SCI/SSCI, EC and INSPEC (2005-2006) databases based on the total relative number of records retrieved from each database. The number of cluster nodes selected for the SCI/SSCI record retrievals equaled 256 (2^8), and 128 (2^7) cluster nodes were selected for both the EC and INSPEC retrievals.

The cluster nodes comprising Levels (0-4) of the SCI/SSCI, EC and INSPEC (2005-2006) database hierarchical taxonomies are described in the following sections. For each of the nodes in the first four levels (0-3), there are two types of data generated by the computer output. The first type of data is ***Syntax*** comprising descriptive terms (Themes their numerical weightings), and phrase groupings). The second type of data is computer-generated ***Metrics*** comprising prolific authors, author countries and affiliations, keywords (author supplied) and journals. Each node in Level 4 (16 leaf nodes) also contains the titles of all the records in the node. Appendices C, D and E provide detailed information on the cluster nodes for the SCI/SSCI, EC and INSPEC (2005-2006) database taxonomies, respectively. Due to the sheer volume of combined information for all databases, only Level 1 and 4 nodes are addressed. In addition, the record titles contained in the Level 4 leaf nodes (48 total), will not be presented; however, having access to the information contained in research article titles for each cluster node, in addition to the syntax and metrics, provides a very powerful capability for analyzing the nodes and gaining in-depth insight to their contents.

4.1.1 SCI/SSCI Document Clustering Results

Figure 57 depicts the first five levels (0-4) of the SCI/SSCI hierarchical taxonomy, with each cluster node representing a technical category. Level 0 is represented by root Cluster 510. There were 256 (2^8) total clusters run for the SCI/SSCI (2005-2006) record retrievals. The number following each depicted cluster heading is the number of records assigned by the clustering algorithm to the category.

Table 22 lists a synopsis of the first four levels of the SCI/SSCI hierarchical taxonomy, and each cell in the matrix lists the representative technical categories. The structure of Table 22 is identical to CLUTO tree depicted in Figure 57, and attempts to show the relationships between clusters (parent/child) and how individual clusters were derived.

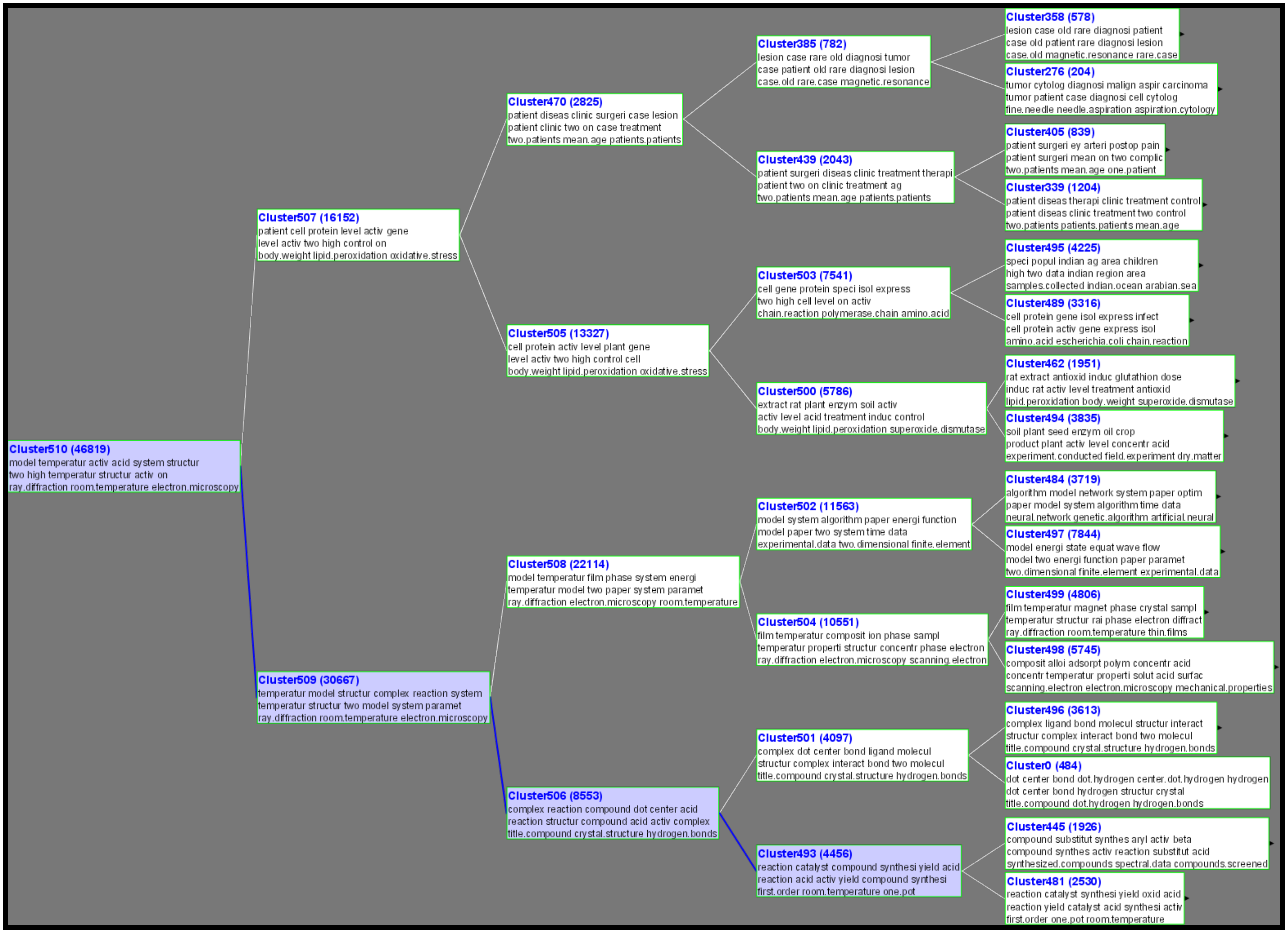

Figure 57. SCI/SSCI (2005-2006) Hierarchical Taxonomy (Levels 0 – 4)

TABLE 22. SCI/SSCI (2005-2006) HIERARCHICAL TAXONOMY (LEVELS 0-4)

SCI/SSCI (2005-2006) Hierarchical Taxonomy (Levels 0 - 4)				
Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
				Cluster {358} - 578 records clinical medicine neurology and neuroscience surgery / pathology
				Cluster {276} - 204 records clinical medicine human patient diseases pathology / oncology
				Cluster {405} - 839 records clinical medicine neurology and neuroscience neurosurgery
				Cluster {339} - 1,204 records clinical medicine human patient diseases pathology
			Cluster {385} - 782 records biomedical research clinical medicine neurology and neuroscience	Cluster {495} - 4,225 records environmental sciences plant sciences / geology / plant biochemistry and biotechnology
		Cluster {470} - 2,825 records biomedical research	Cluster {439} - 2,043 records biomedical research clinical medicine human patient diseases	Cluster {489} - 3,316 records molecular and cellular biochemistry microbiology and biotechnology plant sciences / plant biochemistry and biotechnology
Cluster {510} - 46,819 records PHYSICAL SCIENCES LIFE SCIENCES EARTH SCIENCES MATHEMATICS	Cluster {507} - 16,152 records LIFE SCIENCES EARTH SCIENCES	Cluster {505} - 13,327 records veterinary and animal sciences biology and biochemistry food and agricultural sciences	Cluster {503} - 7,541 records biology and biochemistry food and agricultural sciences molecular and cellular biochemistry microbiology and biotechnology	Cluster {462} - 1,951 records molecular and cellular biochemistry microbiology and biotechnology plant sciences / toxicology and pharmacology
	Cluster {509} - 30,667 records PHYSICAL SCIENCES MATHEMATICS	Cluster {508} - 22,114 records chemistry physics materials science and engineering	Cluster {500} - 5,786 records food and agricultural sciences veterinary and animal sciences molecular and cellular biochemistry	Cluster {494} - 3,835 records microbiology and biotechnology environmental biology / plant sciences / agronomy
		Cluster {506} - 8,553 records chemistry physics materials science and engineering	Cluster {502} - 11,563 records physics scientific and industrial research astronomy and astrophysics nuclear and particle physics	Cluster {484} - 3,719 records scientific and industrial research pattern recognition and machine intelligence
			Cluster {504} - 10,551 records chemistry materials science and engineering physical chemistry thin solid films	Cluster {497} - 7,844 records astronomy and astrophysics nuclear and particle physics plasma physics / high energy physics
			Cluster {501} - 4,097 records chemistry physical chemistry molecular and cellular biochemistry	Cluster {499} - 4,806 records thin solid films crystal growth research and technology nanoscience and nanotechnology
			Cluster {493} - 4,456 records chemistry physical chemistry molecular and cellular biochemistry	Cluster {498} - 5,745 records physical chemistry hazardous materials / colloid and interface science membrane separation and purification technology
				Cluster {496} - 3,613 records physical chemistry molecular liquids / nano-metal chemistry colloid and interface science
				Cluster {0} - 484 records inorganic chemistry physical chemistry crystal growth research and technology / crystallography
				Cluster {445} - 1,926 records molecular and cellular biochemistry organic and biomolecular chemistry pharmaceutical research
				Cluster {481} - 2,530 records physical chemistry molecular and cellular biochemistry molecular synthesis and catalysis / chemical science and kinetics

Based on raw cluster data that includes themes, keywords and journal titles, extended analysis was performed to identify primary (**BLACK**), secondary (blue) and tertiary (red) category headings for the taxonomy depicted in Table 22. The highest level (1) of the taxonomy is the leftmost column, and the lowest level (4) is the rightmost column that contains single-technology associated focus areas. Again, the number following each depicted cluster is the number of records assigned by the clustering algorithm to the category. The following paragraphs provide a summary of the overall taxonomy for Levels 0, 1 and 4.

Level 0 contains the Root cluster with four primary category headings.

Cluster {510} - 46,819 records
PHYSICAL SCIENCES
LIFE SCIENCES
EARTH SCIENCES
MATHEMATICS

Level 1 is divided into two clusters with the following primary and secondary category headings:

Cluster {507} - 16,152 records
Primary: LIFE SCIENCES and EARTH SCIENCES
Secondary: Life Sciences are focused on biology and biochemistry, biomedical research, veterinary and animal sciences, food and agricultural sciences. Earth Sciences are focused on marine science.

Cluster {509} - 30,667 records
Primary: PHYSICAL SCIENCES and MATHEMATICS
Secondary: Physical Sciences are focused on chemistry, physics, and materials science and engineering. Mathematics is focused on applied mathematics and computation science.

Level 4 is divided into sixteen (16) clusters. They are described in order of their listing in Table 22, starting from the top with the following tertiary category headings and single technology focus areas:

Cluster {358} - 578 records
Tertiary: Clinical Medicine, Neurology and Neuroscience cover surgery and pathology with focus on dermatology, radiology and oral medicine.

Cluster {276} - 204 records
Tertiary: Clinical Medicine and Human Patient Diseases cover pathology and oncology with focus on cytology and cytopathology.

Cluster {405} - 839 records
Tertiary: Clinical Medicine, Neurology and Neuroscience cover surgery with focus on cataract and refractive surgery, thoracic surgery, anesthesia and analgesia, neuroradiology and neurosurgery.

Cluster {339} - 1,204 records
Tertiary: Clinical Medicine and Human Patient Diseases cover pathology with focus on gastroenterology, dermatology, hematology and tropical medicine and hygiene.

Cluster {495} - 4,225 records
Tertiary: Environmental Sciences cover plant sciences, plant biochemistry and biotechnology focused on genetic resources and crop evolution; and geology focused on geophysical research.

Cluster {489} - 3,316 records
Tertiary: Molecular and Cellular Biochemistry, and Microbiology and Biotechnology cover plant sciences with focus on plant biochemistry and biotechnology.

Cluster {462} - 1,951 records
Tertiary: Molecular and Cellular Biochemistry, and Microbiology and Biotechnology cover plant sciences with specific focus on ethnopharmacology, phytotherapy research, medicinal food, toxicology and pharmacology.

Cluster {494} - 3,835 records
Tertiary: Microbiology and Biotechnology cover environmental biology and plant sciences with focus on agricultural and food chemistry, and agronomy.

Cluster {484} - 3,719 records
Tertiary: Scientific and Industrial Research covers pattern recognition and machine intelligence with focus on production and operational research. This category also had two dissimilar thrusts including electric power components and applied computing and internet technology.

Cluster {497} - 7,844 records
Tertiary: Astronomy and Astrophysics, and Nuclear and Particle Physics with focus on plasma physics and high energy physics.

Cluster {499} - 4,806 records
Tertiary: Thin Solid Films covers crystal growth research and technology with focus on nanoscience and nanotechnology, superconductor science and technology, and optoelectronics.

Cluster {498} - 5,745 records
Tertiary: Physical chemistry covers hazardous materials with focus on chemical technology, colloid and interface science, and membrane separation and purification technology.

Cluster {496} - 3,613 records
Tertiary: Physical chemistry covers molecular liquids with focus on nano-metal chemistry and colloid and interface science.

Cluster {0} - 484 records
Tertiary: Inorganic Chemistry and Physical Chemistry covers crystal growth research and technology with focus on crystallography, crystal growth and design, and radiation physics (detection) and chemistry.

Cluster {445} - 1,926 records
Tertiary: Molecular and Cellular Biochemistry covers organic and biomolecular chemistry with focus on heterocyclic chemistry, bioorganic and medicinal chemistry, and pharmaceutical research.

Cluster {481} - 2,530 records
Tertiary: Physical Chemistry, and Molecular and Cellular Biochemistry cover molecular synthesis and catalysis with focus on chemical science and kinetics, and medicinal chemistry.

For comparison purposes, Table 23 provides the hierarchical taxonomy for the SCI/SSCI database (2005) obtained during the preceding India Country Study. Note that only tertiary level category headings were previously listed and not specific research focus areas as in this report update. Again, for purpose of brevity, only the categories in Levels 1 and 4 in Table 23 will be summarized.

TABLE 23. SCI/SSCI (2005) HIERARCHICAL TAXONOMY (LEVELS 0 – 4)

Level 0	Level 1	Level 2	Level 3	Level 4
				PLANT BIOLOGY 807 records
				ANIMAL EXPERIMENTS 651records
				CELL BIOLOGY GENETICS 1,168 records
			ANIMAL EXPERIMENTS PLANT BIOLOGY 1,458 records	ALGORITHMS NETWORK MODELING 1,372 records
		BIOLOGICAL RESEARCH 2,626 records	CELL BIOLOGY GENETICS 1,168 records	
ROOT CLUSTER	BIOMEDICAL ENVIRONMENTAL 5,513 records	CLINICAL MEDICINE ENVIRONMENTAL 2,887 records	ALGORITHMS NETWORK MODELING 1,372 records	HUMAN PATIENT DISEASES CLINICAL MEDICINE 1,218 records
	PHYSICAL SCIENCES MATHEMATICS 8,795 records	MATHEMATICS 3,691 records	HUMAN PATIENT DISEASES 1,218 records	
		PHYSICAL SCIENCES 5,104 records	GEOLOGICAL RESEARCH MATERIAL MECHANICS AGRICULTURAL RESEARCH 1,669 records	SOIL/CROP EXPERIMENTS 952 records
			MATHEMATICAL ANALYSIS 2,319 records	GEOLOGICAL RESEARCH MATERIAL MECHANICS 717 records
			SURFACE PHYSICS CHEMISTRY 2,867 records	CONTINUUM ANAYSIS 1,255 records
			COMPOUND CHEMISTRY 2,237 records	MOLECULAR LEVEL CALCULATIONS 1,064 records
				FILM PHYSICS 1,576 records
				FILM CHEMISTRY 1,291 records
				CHEMICAL BONDING / CRYSTAL STRUCTURES 939 records
				REACTIONS/CATALYSIS/SYNTHESIS 1,298 records

Level 1 was divided into two primary categories: Biomedical/ Environment (5513) and Physical Sciences / Mathematics (8795).

- **Biomedical / Environment** covers biological and medical research, as well as agricultural and environmental research.
- **Physical Sciences / Mathematics** covers physics, chemistry, and mathematics, with a strong emphasis on the physics and chemistry of surfaces.

Level 4 was divided into 16 primary categories. They are described in order of their listing in Table 23, starting from the top.

- **Plant Biology (807) -** Focuses on plants and seeds, especially the extraction of oils from seeds, and has a food technology emphasis.

- **Animal Experiments (651) -** Focuses on laboratory experiments for addressing diseases especially for testing the impacts of drugs.
- **Cell Biology / Genetics (1168) -** Focuses on cell biology and genetics, especially proteins and gene expression. It is one of the more fundamental research categories, as evidenced by the journals and terminology.
- **Algorithms / Network Modeling (1372) -** Focuses on algorithms and modeling of networks, especially communications.
- **Human Patient Diseases (1218) -** Focuses on clinical patient treatment, with emphasis on treatment of infections, especially HIV.
- **Soil/ Crop Experiments (952) -** Focuses on the study of soils and plant genetics to improve crop yields. It is more fundamental than the related Plant Biology category, as evidenced by the major journals, keywords, and institutions.
- **Geological Research / Material Mechanics (717) -** This category had two dissimilar thrusts: Geological and associated environmental research, and the mechanics of materials. The geological thrust focuses on sediments, and the materials thrust focuses on welding.
- **Continuum Analysis (1255) -** Focuses on equations modeling continuum fields, especially flow fields and wave equations.
- **Molecular Level Calculations (1064) -** Focuses on energy states, and calculations at the atomic and molecular level.
- **Film Physics (1576) -** Focuses on surface and film physics. Main thrusts are small-scale film measurements and film deposition and growth.
- **Film Chemistry (1291) -** Focuses on film chemistry, mainly polymer chemistry/properties, and surface wet chemistry.
- **Chemical Bonds/ Crystal Structures (939) -** Focuses on chemical bonds and crystal structures, emphasizing ligand-metal complex synthesis and compound hydrogen bonds.
- **Reactions / Catalysis / Synthesis (1298) -** Focuses on Applied organic chemistry category, emphasizing chemical reactions, catalysis, and synthesis.

As expected, by comparing Tables 22 and 23, it can be seen that the overall hierarchical taxonomies (Levels 0-4) were essentially maintained between SCI/SSCI (2005) and SCI/SSCI (2005-2006) even by just comparing the primary category headings. For reference purposes, Appendix C provides detailed cluster category descriptions provided by the CLUTO algorithm for the SCI/SSCI (2005-2006) taxonomy (Levels 1 and 4). The category descriptions for Level 1 below contain two types of phrases: 1) THEMES are the key computer-generated phrases for the category, and they determined the category theme (their numerical weightings are also included), and 2) KEYWORDS are the article author-supplied keywords for the articles in the category. The category descriptions for Level 4 contain the bibliometrics for the category (e.g. affiliations, authors, journals, etc.), as well as select key phrases (Top 20 Themes and Top 30 keywords).

The following sections provide the clustering results obtained from the EC and INSPEC (2005-2006) datasets. The hierarchical taxonomies for each dataset are presented in both depictions and tabular listings, and are identical to the SCI/SSCI format to allow direct comparison between all three datasets.

4.1.2 EC Document Clustering Results

Figure 58 depicts the first five levels (0-4) of the EC hierarchical taxonomy, with each cluster representing a technical category. Level 0 is represented by root Cluster 254. There were 256 (2^8) total clusters run for the EC (2005-2006) record retrievals. The number following each depicted cluster heading is the number of records assigned by the clustering algorithm to the category.

Table 24 lists a synopsis of the first four levels of the EC hierarchical taxonomy, where each cell in the matrix lists the representative technical categories. The structure of Table 24 is identical to CLUTO tree depicted in Figure 58, and attempts to show the relationships between clusters (parent/child) and how individual clusters were derived. In the following discussion, the categories in Levels 1 and 4 will be described.

For reference purposes, Appendix D provides detailed cluster category descriptions provided by the CLUTO algorithm for the EC (2005-2006) taxonomy (Levels 1 and 4). The category descriptions for Level 1 below contain two types of phrases: 1) THEMES are the key computer-generated phrases for the category, and they determined the category theme (their numerical weightings are also included); and 2) KEYWORDS are the article author-supplied keywords for the articles in the category. The category descriptions for Level 4 contain the bibliometrics for the category (e.g. affiliations, authors, journals, etc.), as well as select key phrases (Top 20 Themes and Top 30 Keywords). Note that author country bibliometrics are not included since this is a single-valued field in the EC database (one author country per record).

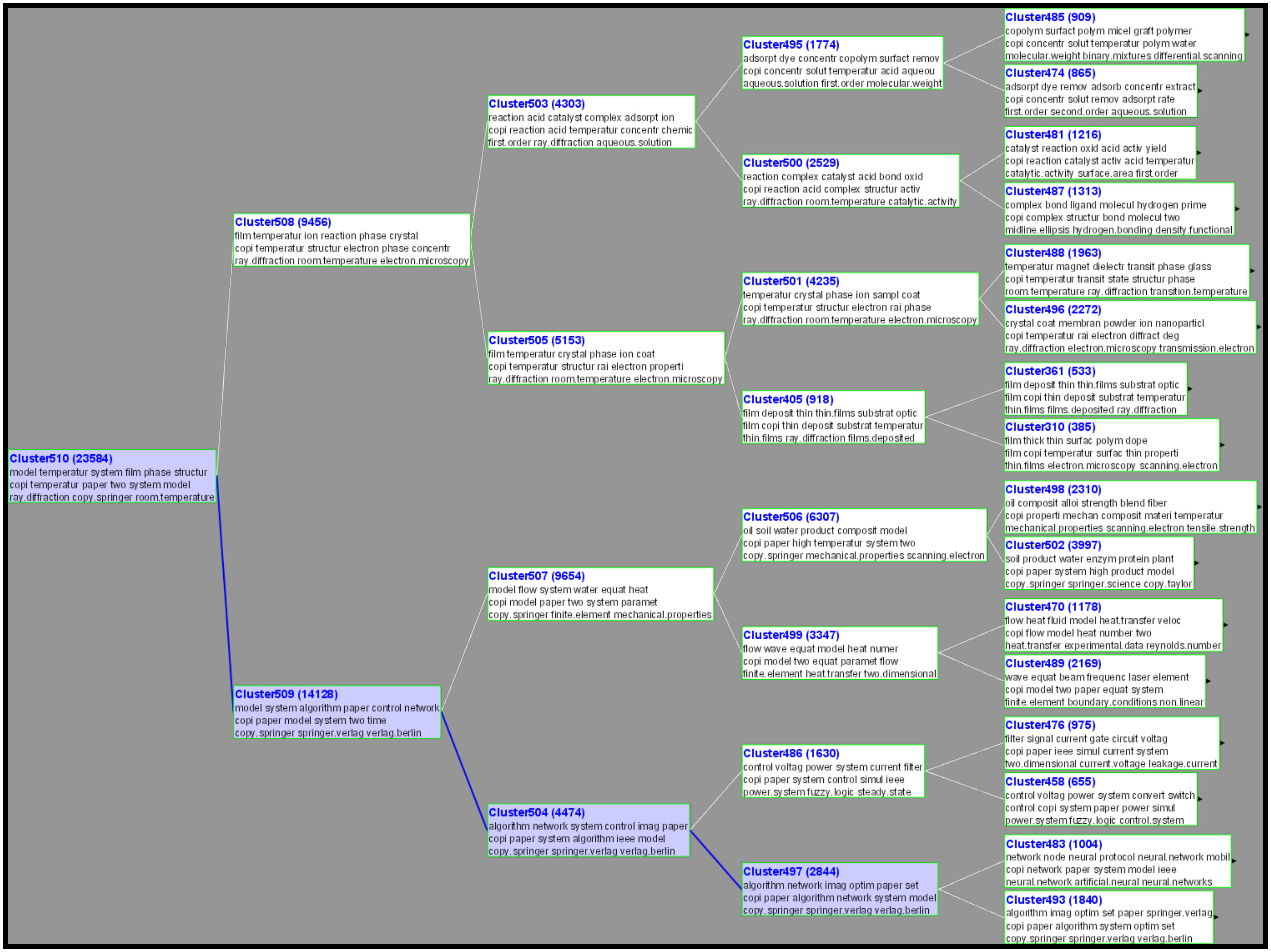

Figure 58. EC (2005-2006) Hierarchical Taxonomy (Levels 0-4)

TABLE 24. EC (2005-2006) HIERARCHICAL TAXONOMY (LEVELS 0-4)

Engineering Compendex (2005-2006) Hierarchical Taxonomy (Levels 0 - 4)

Level 0	Level 1	Level 2	Level 3	Level 4
				Cluster {485} - 909 records chemical synthesis colloid and interface science reaction kinetics / surface active agents / surfactants
				Cluster {474} - 865 records colloid and interface science reaction kinetics / surface active agents / surfactants separation and purification techniques
				Cluster {481} - 1,216 records organic compounds chemical synthesis molecular catalysis / chemical oxidation and reaction kinetics
				Cluster {487} - 1,313 records organic compounds chemical synthesis molecular organic crystals
			Cluster {495} - 1,774 records physical chemistry polymer science and technology chemical synthesis colloid and interface science	Cluster {488} - 1,963 records chemical synthesis/doping polycrystalline and nanostructured materials ferroelectric and magnetic materials
		Cluster {503} - 4,303 records physical chemistry polymer science and technology	Cluster {500} - 2,529 records polymer science and technology organic compounds chemical synthesis	Cluster {496} - 2,272 records chemical synthesis/doping polycrystalline and nanostructured materials crystal structure and growth research single crystals and surface coatings
Cluster {510} - 23,584 records APPLIED PHYSICAL SCIENCES CHEMICAL ENGINEERING COMPUTERS AND DATA PROCESSING AGRICULTURE ENGINEERING & FOOD TECHNOLOGY ELECTRONICS & COMMUNICATION ENGINEERING	Cluster {508} - 9,456 records APPLIED PHYSICAL SCIENCES CHEMICAL ENGINEERING	Cluster {505} - 5,153 records physical chemistry materials engineering	Cluster {501} - 4,235 records physical chemistry materials engineering chemical synthesis/doping polycrystalline and nanostructured materials	Cluster {361} - 533 records polycrystalline and nanostructured materials thin solid films solar energy / solar cell research / deposition techniques
	Cluster {509} - 14,128 records COMPUTERS AND DATA PROCESSING AGRICULTURE ENGINEERING & FOOD TECHNOLOGY ELECTRONICS & COMMUNICATION ENGINEERING	Cluster {507} - 9,654 records applied computation polymer science and technology food science and technology	Cluster {405} - 918 records materials engineering polycrystalline and nanostructured materials thin solid films	Cluster {310} - 385 records nanostructured materials thin solid films semi-conductor materials / sol-gels electrochemistry and electrodeposition
		Cluster {504} - 4,474 records applied computation communications	Cluster {506} - 6,307 records polymer science and technology food science and technology organic compounds microbiology and biotechnology	Cluster {498} - 2,310 records organic compounds polymer composites and plastics / materials characterization
			Cluster {499} - 3,347 records applied computation chemical engineering mathematical models and computer simulation	Cluster {502} - 3,997 records microbiology and biotechnology agronomy / plant biochemistry and biotechnology environmental biology / genetic resources and crop evolution
			Cluster {486} - 1,630 records applied computation communications mathematical models and computer simulation telecommunications	Cluster {470} - 1,178 records chemical engineering mathematical models and computer simulation computational fluid dynamics / heat mass transfer
			Cluster {497} - 2,844 records applied computation communications mathematical models and computer simulation telecommunications	Cluster {489} - 2,169 records mathematical models and computer simulation computational fluid dynamics / plasma physics Monte Carlo and molecular dynamics
				Cluster {476} - 975 records mathematical models and computer simulation telecommunications microelectronics / VLSI Circuit Design
				Cluster {458} - 655 records mathematical models and computer simulation electrical power and distribution systems fuzzy and intelligent control
				Cluster {483} - 1,004 records mathematical models and computer simulation telecommunications artificial intelligence / neural networks wireless telecommunication networks
				Cluster {493} - 1,840 records mathematical models and computer simulation pattern recognition and machine intelligence artificial intelligence / genetic algorithms / remote sensing information retrieval / data mining

Based on raw cluster data that includes themes, keywords and journal titles, extended analysis was performed to identify primary (BLACK), secondary (blue) and tertiary (red) category headings for the taxonomy depicted in Table 24. The highest level (1) of the taxonomy is the leftmost column, and the lowest level (4) is the rightmost column that contains single-technology associated focus areas. Again, the number following each depicted cluster is the number of records assigned by the clustering algorithm to the category. The following paragraphs provide a summary of the overall taxonomy for Levels 0, 1 and 4.

Level 0 contains the Root cluster with five primary category headings.

Cluster {510} - 23,584 records
APPLIED PHYSICAL SCIENCES
CHEMICAL ENGINEERING
COMPUTERS AND DATA PROCESSING
AGRICULTURE ENGINEERING & FOOD TECHNOLOGY
ELECTRONICS & COMMUNICATION ENGINEERING

Level 1 is divided into two clusters with the following primary and secondary category headings:

Cluster {508} - 9,456 records
Primary: APPLIED PHYSICAL SCIENCES and CHEMICAL ENGINEERING
Secondary: Physical Chemistry, Materials Engineering and Polymer Science and Technology.

Cluster {509} - 14,128 records
Primary: COMPUTERS AND DATA PROCESSING, AGRICULTURE ENGINEERING & FOOD TECHNOLOGY, and ELECTRONICS & COMMUNICATION ENGINEERING.
Secondary: Applied Computation, Polymer Science and Technology, Food Science and Technology, and Communications.

Level 4 is divided into sixteen (16) clusters. They are described in order of their listing in Table 24, starting from the top with the following tertiary category headings and single technology focus areas:

Cluster {485} - 909 records
Tertiary: Chemical Synthesis, and Colloid and Interface Science covers reaction kinetics and surface active agents / surfactants with focus on polymerization and monomers.

Cluster {474} - 865 records
Tertiary: Colloid and Interface Science covers reaction kinetics and surface active agents/surfactants with focus on separation and purification techniques and chromatography.

Cluster {481} - 1,216 records
Tertiary: Organic Compounds and Chemical Synthesis covers molecular catalysis with focus on chemical oxidation and reaction kinetics, catalysts and organic solvents.

Cluster {487} - 1,313 records
Tertiary: Organic Compounds and Chemical Synthesis with focus on molecular organic crystals, molecular and crystal structure and molecular and biomolecular spectroscopy.

Cluster {488} - 1,963 records
Tertiary: Chemical Synthesis/Doping and Polycrystalline, and Nanostructured Materials with focus on ferroelectric and magnetic materials.

Cluster {496} - 2,272 records
Tertiary: Chemical Synthesis/Doping and Polycrystalline, and Nanostructured Materials covers crystal structure and growth research with focus on single crystals and surface coatings.

Cluster {361} - 533 records
Tertiary: Polycrystalline and Nanostructured Materials and Thin Solid Films covers solar energy / solar cell research with focus on deposition techniques and optical properties.

Cluster {310} - 385 records
Tertiary: Nanostructured Materials and Thin Solid Films cover solid-state/semi-conductor materials, with focus on electrochemistry, electrodeposition and sol-gels.

Cluster {498} - 2,310 records
Tertiary: Organic Compounds with focus on polymer composites and plastics, materials characterization and microstructure and material properties.

Cluster {502} - 3,997 records
Tertiary: Microbiology and Biotechnology covers agronomy/plant and food sciences and environmental biology with focus on plant biochemistry and biotechnology, genetic resources and crop evolution. Environmental monitoring and impact assessment covers computer simulation and modeling of rain/ground water (ph effects, adsorption, and contamination).

Cluster {470} - 1,178 records
Tertiary: Chemical Engineering and Mathematical Models and Computer Simulation covers computational fluid dynamics with focus on heat mass transfer.

Cluster {489} - 2,169 records
Tertiary: Mathematical Models and Computer Simulation covers computational fluid dynamics with focus on microwave optics, plasma physics and Monte Carlo and molecular dynamics simulations.

Cluster {476} - 975 records
Tertiary: Mathematical Models and Computer Simulation, and Telecommunications covers microelectronics with focus on VLSI circuit design.

Cluster {458} - 655 records
Tertiary: Mathematical Models and Computer Simulation covers electrical power and distribution systems with focus on fuzzy and intelligent control and instruments and measurement.

Cluster {483} - 1,004 records
Tertiary: Mathematical Models and Computer Simulation, and Telecommunications covers artificial intelligence and wireless telecommunication networks with focus on neural networks and wireless network optimization.

Cluster {493} - 1,840 records
Tertiary: Mathematical Models and Computer Simulation covers pattern recognition and machine intelligence, and artificial intelligence with focus on genetic algorithms, intelligent remote sensing, and information retrieval/data mining.

4.1.3 INSPEC Document Clustering Results

Figure 59 depicts the first five levels (0-4) of the INSPEC hierarchical taxonomy, with each cluster representing a technical category. Level 0 is represented by root Cluster 254. There were 128 (2^7) total clusters run for the INSPEC (2005-2006) record retrievals. The number following each depicted cluster heading is the number of records assigned by the clustering algorithm to the category. Table 25 lists a synopsis of the first four levels of the INSPEC hierarchical taxonomy, where each cell in the matrix lists the representative technical categories. The structure of Table 25 is identical to CLUTO tree depicted in Figure 59, and attempts to show the relationships between clusters (parent/child) and how individual clusters were derived. In the following discussion, the categories in Levels 1 and 4 will be described.

For reference purposes, Appendix E provides detailed cluster category descriptions provided by the CLUTO algorithm for the INSPEC (2005-2006) taxonomy (Levels 1 and 4). The category descriptions for Level 1 below contain two types of phrases: 1) THEMES are the key computer-generated phrases for the category, and they determined the category theme (their numerical weightings are also included), and 2) KEYWORDS are the article author-supplied keywords for the articles in the category. The category descriptions for Level 4 contain the bibliometrics (e.g. affiliations, authors, journals, etc.), as well as select key phrases (Top 20 Themes and Top 30 keywords). Note that author country bibliometrics are not included since this is a single-valued field in the INSPEC database (one author country per record).

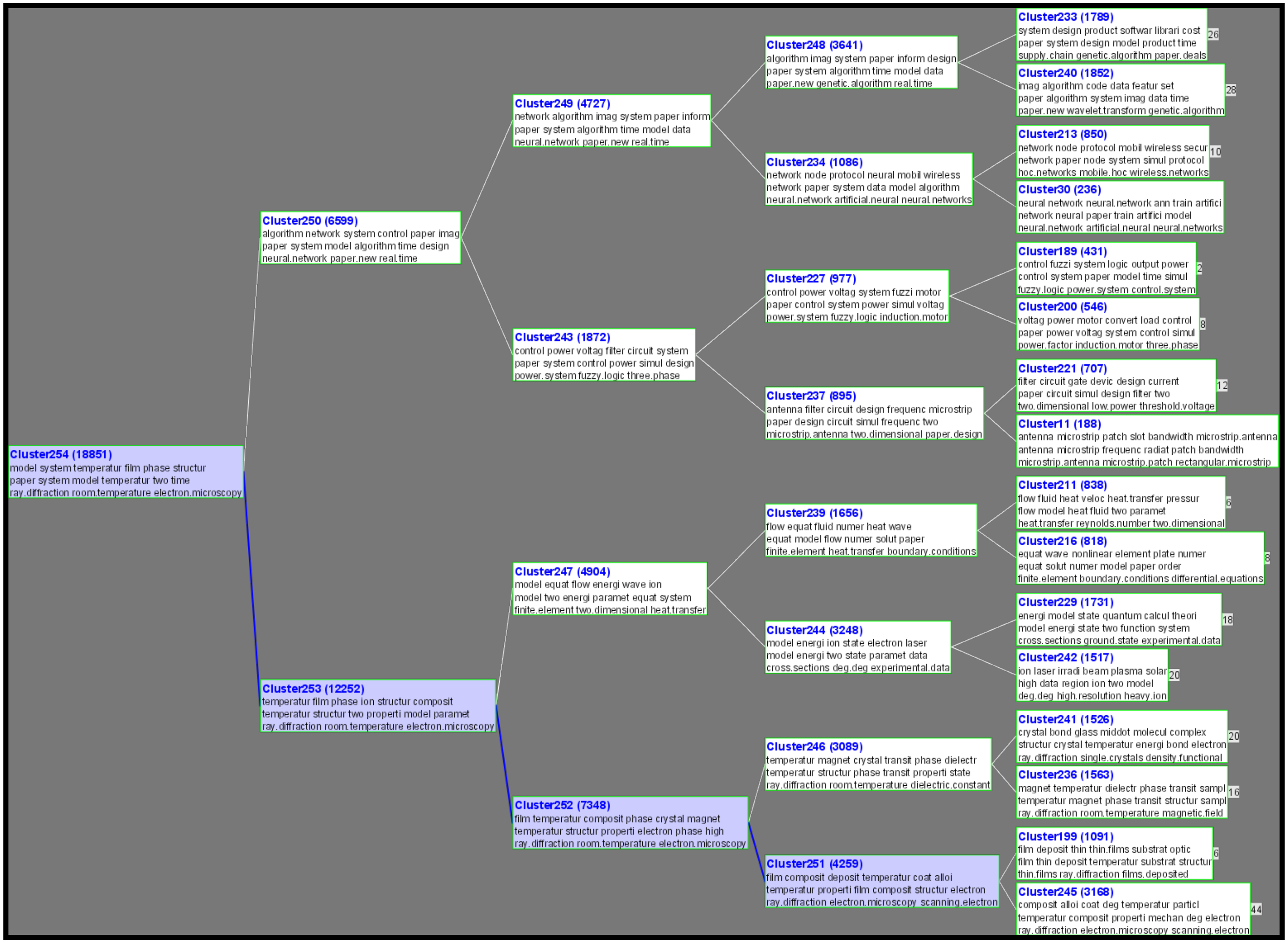

Figure 59. INSPEC (2005-2006) Hierarchical Taxonomy (Levels 0-4)

TABLE 25. INSPEC (2005-2006) HIERARCHICAL TAXONOMY (LEVELS 0-4)

INSPEC (2005-2006) Hierarchical Taxonomy (Levels 0 - 4)				
Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
				Cluster {233} - 1,789 records information technology scientific and industrial research inventory and supply chain management / genetic algorithms food processing technology / soil research
				Cluster {240} - 1,852 records scientific and industrial research information technology signal and image processing pattern recognition and machine intelligence
				Cluster {213} - 850 records telecommunications wireless and photonic sensor networks
				Cluster {30} - 236 records scientific and industrial research information technology signal and image processing pattern recognition and machine intelligence
			Cluster {248} - 3,641 records advanced manufacturing technology computers and computation scientific and industrial research information technology	Cluster {189} - 431 records electric power systems and components electric power distribution and control linear and non-linear control systems
		Cluster {249} - 4,727 records advanced manufacturing technology computers and computation communications	Cluster {234} - 1,086 records advanced manufacturing technology communications telecommunications microwave and optical technology	Cluster {200} - 546 records electric power systems and components electric power distribution and control fuzzy and intelligent control / computer simulation
Cluster {254} - 18,851 records APPLIED PHYSICAL SCIENCES ELECTRICAL ENGINEERING COMPUTERS AND DATA PROCESSING ELECTRONICS PRODUCTION AND MANUFACTURING	Cluster {250} - 6,599 records COMPUTERS AND DATA PROCESSING PRODUCTION AND MANUFACTURING ELECTRICAL ENGINEERING ELECTRONICS	Cluster {243} - 1,872 records advanced manufacturing technology communications	Cluster {227} - 977 records advanced manufacturing technology scientific and industrial research electric power systems and components	Cluster {221} - 707 records solid-state / semi-conductor materials and devices microelectronics / VLSI Circuit Design
	Cluster {253} - 12,252 records APPLIED PHYSICAL SCIENCES	Cluster {247} - 4,904 records physical chemistry	Cluster {237} - 895 records advanced manufacturing technology materials engineering microwave and optical technology solid-state / semi-conductor materials and devices	Cluster {11} - 188 records microwave and optical technology microwave/microstrip antenna design radio space physics / electromagnetic wave propagation
		Cluster {252} - 7,348 records physical chemistry materials engineering	Cluster {239} - 1,656 records physics physical chemistry structural design and analysis chemical engineering physics of fluids	Cluster {211} - 838 records chemical engineering physics of fluids computational fluid dynamics plasma physics / magnetohydrodynamics / heat mass transfer
			Cluster {244} - 3,248 records physics materials engineering nuclear and particle physics astronomy and astrophysics solid-state/semi-conductor materials and devices	Cluster {216} - 818 records structural design and analysis composites and plastics finite element analysis
			Cluster {246} - 3,089 records physical chemistry materials engineering organic compounds crystal growth	Cluster {229} - 1,731 records nuclear and particle physics astronomy and astrophysics plasma physics / radio space physics / cosmology
			Cluster {251} - 4,259 records materials engineering organic compounds crystal growth thin solid films	Cluster {242} - 1,517 records astronomy and astrophysics plasma physics / radio space physics / cosmology earthquake and seismology research
				Cluster {241} - 1,526 records organic compounds crystal growth polycrystalline and nanostructured materials molecular organic crystals
				Cluster {236} - 1,563 records solid-state/semi-conductor materials and devices ferromagnetic materials superconductor science and technology
				Cluster {199} - 1,091 records thin solid films solid-state/semi-conductor materials and devices materials characterization solar energy / solar cell research
				Cluster {245} - 3,168 records organic compounds polymer science and technology / composites and plastics microstructure and material properties

Based on raw cluster data that includes themes, keywords and journal titles, extended analysis was performed to identify primary (BLACK), secondary (blue) and tertiary (red) category headings for the taxonomy depicted in Table 25. The highest level (1) of the taxonomy is the leftmost column, and the lowest level (4) is the rightmost column that contains single-technology associated focus areas. Again, the number following each depicted cluster is the number of records assigned by the clustering algorithm to the category. The following paragraphs provide a summary of the overall taxonomy for Levels 0, 1 and 4.

Level 0 contains the Root cluster with five primary category headings.

Cluster {254} - 18,851 records

APPLIED PHYSICAL SCIENCES
ELECTRICAL ENGINEERING
COMPUTERS AND DATA PROCESSING
ELECTRONICS
PRODUCTION AND MANUFACTURING

Level 1 is divided into two clusters with the following primary and secondary category headings:

Cluster {250} - 6,599 records
Primary: COMPUTERS AND DATA PROCESSING, PRODUCTION AND MANUFACTURING, ELECTRICAL ENGINEERING and ELECTRONICS.
Secondary: Computers and Data Processing is focused on computation. Production and Manufacturing is focused on advanced manufacturing technology. Electronics is focused on communications.

Cluster {253} - 12,252 records
Primary: APPLIED PHYSICAL SCIENCES
Secondary: Physical Chemistry and Materials Engineering.

Level 4 is divided into sixteen (16) clusters. They are described in order of their listing in Table XY, starting from the top with the following tertiary category headings and single technology focus areas:

Cluster {233} - 1,789 records
Tertiary: Information technology covers inventory and supply chain management and with focus on genetic algorithms. Scientific and Industrial Research covers Food processing technology with focus on dairy products and vegetable oils, and soil contamination/pollution experiments.

Cluster {240} - 1,852 records
Tertiary: Scientific and Industrial Research and Information Technology covers signal and image processing with focus on pattern recognition and machine intelligence and data mining.

Cluster {213} - 850 records
Tertiary: Telecommunications covers wireless sensor networks and photonic sensor networks with focus on cryptography.

Cluster {30} - 236 records
Tertiary: Scientific and Industrial Research and Information Technology covers signal and image processing with focus on pattern recognition and machine intelligence, genetic algorithms and artificial intelligence.

Cluster {189} - 431 records
Tertiary: Electric Power Systems and Components covers electric power distribution and control with focus on linear and non-linear control systems and smart materials.

Cluster {200} - 546 records
Tertiary: Electric Power Systems and Components covers electric power distribution and control with focus on fuzzy and intelligent control and computer simulation.

Cluster {221} - 707 records
Tertiary: Solid-State / Semi-Conductor Materials and Devices covers microelectronics with focus on VLSI Circuit Design.

Cluster {11} - 188 records
Tertiary: Microwave and Optical Technology covers microwave/microstrip antenna design with focus on radio space physics and electromagnetic wave propagation.

Cluster {211} - 838 records
Tertiary: Chemical Engineering and Physics of Fluids covers computational fluid dynamics, plasma physics, magnetohydrodynamics and heat mass transfer.

Cluster {216} - 818 records
Tertiary: Structural Design and Analysis with focus on composites and plastics and finite element analysis.

Cluster {229} - 1,731 records
Tertiary: Nuclear and Particle Physics and Astronomy and Astrophysics with focus on plasma physics, radio space physics and cosmology.

Cluster {242} - 1,517 records
Tertiary: Astronomy and Astrophysics with focus on plasma physics, radio space physics, cosmology, and earthquake and seismology research.

Cluster {241} - 1,526 records
Tertiary: Organic Compounds and Crystal Growth covers polycrystalline and nanostructured materials, and molecular organic crystals with focus on molecular and biomolecular spectroscopy, and x-ray diffraction analysis.

Cluster {236} - 1,563 records
Tertiary: Solid-State/Semi-Conductor Materials and Devices covers ferromagnetic materials with focus on x-ray diffraction analysis, electron/atomic force microscopy, and superconductor science and technology.

Cluster {199} - 1,091 records
Tertiary: Thin Solid Films and Solid-State/Semi-Conductor Materials and Devices with focus on x-ray diffraction analysis, electron/atomic force microscopy, and solar energy / solar cell research.

Cluster {245} - 3,168 records
Tertiary: Organic Compounds with focus on polymer science and technology, composites and plastics, and microstructure and material properties.

4.1.4 Summary of Document Clustering Results

The following paragraphs provide a summary of the CLUTO document clustering analysis results. The summary compares the SCI/SSCI, EC and INSPEC database taxonomies by identifying clusters common and unique to all databases. The comparison also addresses the differences in thrusts of each database. Lastly, based on common Level 4 database clusters, predominant S&T investment areas are identified for associated Central government S&T departments and agencies.

The taxonomy generated for the SCI/SSCI database reflects focus on four (4) primary category headings including:

1. Physical Sciences (chemistry, physics, and materials science)
2. Life Sciences (biology and biochemistry, biomedical research, veterinary and animal sciences, food and agricultural sciences)
3. Earth Sciences (marine science, geology)
4. Mathematics (applied and computational)

The taxonomy generated for the EC and INSPEC databases reflect focus on six (6) primary category headings including:

1. Applied Physical Sciences (physical chemistry, materials engineering)
2. Chemical Engineering (polymer science and technology)
3. Computers and Data Processing (modeling & simulation)
4. Agriculture Engineering and Food Technology (plant biochemistry and biotechnology, food sciences, environmental biology)
5. Electronics and Communication Engineering (microelectronics and wireless telecommunications)
6. Production and Manufacturing (scientific and industrial research, advanced manufacturing technology)

The following paragraphs provide a listing of the unique clusters with a brief description of associated themes for all databases.

SCI/SSCI Database:

Cluster {358} - 578 records
Theme: Clinical Medicine, Neurology and Neuroscience cover surgery and pathology with focus on dermatology, radiology and oral medicine.

Cluster {405} - 839 records
Theme: Clinical Medicine, Neurology and Neuroscience cover surgery with focus on cataract and refractive surgery, thoracic surgery, anesthesia and analgesia, neuroradiology and neurosurgery.

Cluster {276} - 204 records
Theme: Clinical Medicine and Human Patient Diseases cover pathology and oncology with focus on cytology and cytopathology.

Cluster {339} - 1,204 records
Theme: Clinical Medicine and Human Patient Diseases cover pathology with focus on gastroenterology, dermatology, hematology and tropical medicine and hygiene.

EC Database:

Cluster {498} - 2,310 records
Theme: Organic Compounds with focus on polymer composites and plastics, materials characterization and microstructure properties.

INSPEC Database:

Cluster {216} - 818 records
Theme: Structural Design and Engineering with focus on composites and plastics, and finite element analyses.

Cluster {245} - 3,168 records
Theme: Organic Compounds with focus on polymer science and technology, composites and plastics, and microstructure and material properties.

The following paragraphs provide a listing and brief description of the eight (8) common cluster themes (Level 4) for all databases.

1. **Environmental Sciences, Molecular/Cellular Biochemistry, Microbiology and Biotechnology**

SCI/SSCI Cluster {495} - 4,225 records
Theme: Environmental Sciences cover plant sciences, plant biochemistry and biotechnology focused on genetic resources and crop evolution; and geology focused on geophysical research.
SCI/SSCI Cluster {489} - 3,316 records
Theme: Molecular and Cellular Biochemistry, and Microbiology and Biotechnology cover plant sciences with focus on plant biochemistry and biotechnology.
SCI/SSCI Cluster {462} - 1,951 records
Theme: Molecular and Cellular Biochemistry, and Microbiology and Biotechnology cover plant sciences with specific focus on ethnopharmacology, phytotherapy research, medicinal food, toxicology and pharmacology.
SCI/SSCI Cluster {494} - 3,835 records
Theme: Microbiology and Biotechnology cover environmental biology and plant sciences with focus on agricultural and food chemistry, and agronomy.
EC Cluster {502} - 3,997 records
Theme: Microbiology and Biotechnology covers agronomy/plant and food sciences and environmental biology with focus on plant biochemistry and biotechnology, genetic resources and crop evolution. Environmental monitoring and impact assessment covers computer simulation and modeling of rain/ground water (ph effects, adsorption, and contamination).

2. **Scientific and Industrial Research, Information Technology**

SCI/SSCI Cluster {484} - 3,719 records
Theme: Scientific and Industrial Research covers pattern recognition and machine intelligence with focus on production and operational research. This category also had two dissimilar thrusts including electric power components and applied computing and information/internet technology.
EC Cluster {493} - 1,840 records
Theme: Mathematical Models and Computer Simulation covers pattern recognition and machine intelligence, and artificial intelligence with focus on genetic algorithms, intelligent remote sensing, and information retrieval/data mining.
EC Cluster {458} - 655 records
Theme: Mathematical Models and Computer Simulation covers electrical power and distribution systems with focus on fuzzy and intelligent control and instruments and measurement.
INSPEC Cluster {240} - 1,852 records
Theme: Scientific and Industrial Research and Information Technology covers signal and image processing with focus on pattern recognition and machine intelligence and data mining.

INSPEC Cluster {233} - 1,789 records
Theme: Information technology covers inventory and supply chain management and with focus on genetic algorithms. Scientific and Industrial Research covers Food processing technology with focus on dairy products and vegetable oils, and soil contamination/pollution experiments.

INSPEC Cluster {30} - 236 records
Theme: Scientific and Industrial Research and Information Technology covers signal and image processing with focus on pattern recognition and machine intelligence, genetic algorithms and artificial intelligence.

INSPEC Cluster {189} - 431 records
Theme: Electric Power Systems and Components covers electric power distribution and control with focus on linear and non-linear control systems and smart materials.

INSPEC Cluster {200} - 546 records
Theme: Electric Power Systems and Components covers electric power distribution and control with focus on fuzzy and intelligent control and computer simulation.

3. Astronomy and Astrophysics, Nuclear and Particle Physics

SCI/SSCI Cluster {497} - 7,844 records
Theme: Astronomy and Astrophysics, and Nuclear and Particle Physics with focus on plasma physics and high energy physics.

EC Cluster {489} - 2,169 records
Theme: Mathematical Models and Computer Simulation covers computational fluid dynamics with focus on plasma physics, and Monte Carlo / molecular dynamics simulations.

INSPEC Cluster {229} - 1,731 records
Theme: Nuclear and Particle Physics and Astronomy and Astrophysics with focus on plasma physics, radio space physics and cosmology.

INSPEC Cluster {242} - 1,517 records
Theme: Astronomy and Astrophysics with focus on plasma physics, radio space physics, cosmology, and earthquake and seismology research.

INSPEC Cluster {11} - 188 records
Theme: Microwave and Optical Technology covers microwave/microstrip antenna design with focus on radio space physics and electromagnetic wave propagation.

4. Thin Solid Films, Polycrystalline and Nanostructured Materials

SCI/SSCI Cluster {499} - 4,806 records
Theme: Thin Solid Films covers crystal growth research and technology with focus on nanoscience and nanotechnology, superconductor science and technology, and optoelectronics.

EC Cluster {361} - 533 records
Theme: Polycrystalline and Nanostructured Materials and Thin Solid Films covers solar energy / solar cell research with focus on deposition techniques and optical properties.

EC Cluster {310} - 385 records
Theme: Nanostructured Materials and Thin Solid Films cover solid-state/semi-conductor materials, with focus on electrochemistry, electrodeposition and sol-gels.

INSPEC Cluster {236} - 1,563 records
Theme: Solid-State/Semi-Conductor Materials and Devices covers ferromagnetic materials with focus on x-ray diffraction analysis, electron/atomic force microscopy, and superconductor science and technology.
INSPEC Cluster {199} - 1,091 records
Theme: Thin Solid Films and Solid-State/Semi-Conductor Materials and Devices with focus on x-ray diffraction analysis, electron/atomic force microscopy, and solar energy / solar cell research.

5. Physical Chemistry, Colloid and Interface Science

SCI/SSCI Cluster {498} - 5,745 records
Theme: Physical chemistry covers hazardous materials with focus on chemical technology, colloid and interface science, and membrane separation and purification technology.
SCI/SSCI Cluster {496} - 3,613 records
Theme: Physical chemistry covers molecular liquids with focus on nano-metal chemistry and colloid and interface science.
EC Cluster {485} - 909 records
Theme: Chemical Synthesis, and Colloid and Interface Science cover reaction kinetics and surface-active agents / surfactants with focus on polymerization and monomers.
EC Cluster {474} - 865 records
Theme: Colloid and Interface Science covers reaction kinetics and surface-active agents/surfactants with focus on separation and purification techniques and chromatography.

6. Polycrystalline and Nanostructured Materials, Organic Compounds

SCI/SSCI Cluster {0} - 484 records
Theme: Inorganic Chemistry and Physical Chemistry covers crystal growth research and technology with focus on crystallography, crystal growth and design, and radiation physics (detection) and chemistry.
EC Cluster {488} - 1,963 records
Theme: Chemical Synthesis/Doping, and Polycrystalline and Nanostructured Materials with focus on ferroelectric and magnetic materials.
EC Cluster {496} - 2,272 records
Theme: Chemical Synthesis/Doping, and Polycrystalline and Nanostructured Materials covers crystal structure and growth research with focus on single crystals and surface coatings.
EC Cluster {487} - 1,313 records
Theme: Organic Compounds and Chemical Synthesis with focus on molecular organic crystals, molecular and crystal structure and molecular and biomolecular spectroscopy.
INSPEC Cluster {241} - 1,526 records
Theme: Organic Compounds and Crystal Growth covers polycrystalline and nanostructured materials, and molecular organic crystals with focus on molecular and biomolecular spectroscopy, and x-ray diffraction analysis.

7. **Molecular and Cellular Biochemistry, Organic Compounds, Chemical Synthesis**

SCI/SSCI Cluster {445} - 1,926 records
Theme: Molecular and Cellular Biochemistry covers organic and biomolecular chemistry with focus on heterocyclic chemistry, bioorganic and medicinal chemistry, and pharmaceutical research.
SCI/SSCI Cluster {481} - 2,530 records
Theme: Physical Chemistry, and Molecular and Cellular Biochemistry cover molecular synthesis and catalysis with focus on chemical science and kinetics, and medicinal chemistry.
EC Cluster {481} - 1,216 records
Theme: Organic Compounds and Chemical Synthesis covers molecular catalysis with focus on chemical oxidation and reaction kinetics, catalysts and organic solvents.

8. **Computer Simulation, Telecommunications, Microelectronics**

EC Cluster {476} - 975 records
Theme: Mathematical Models and Computer Simulation, and Telecommunications covers microelectronics with focus on VLSI circuit design.
EC Cluster {483} - 1,004 records
Theme: Mathematical Models and Computer Simulation, and Telecommunications covers artificial intelligence and wireless telecommunication networks with focus on neural networks and wireless network optimization.
INSPEC Cluster {221} - 707 records
Theme: Solid-State / Semi-Conductor Materials and Devices covers microelectronics with focus on VLSI Circuit Design.
INSPEC Cluster {213} - 850 records
Theme: Telecommunications covers wireless sensor networks and photonic sensor networks with focus on cryptography.

Lastly, based on common Level 4 database clusters, predominant investment areas were identified for associated Central government S&T departments and agencies as follows:

Dept. of Science and Technology (S&T)

- Thin Solid Films, Polycrystalline and Nanostructured Materials
- Physical Chemistry, Colloid and Interface Science
- Polycrystalline and Nanostructured Materials, Organic Compounds
- Molecular and Cellular Biochemistry, Chemical Synthesis
- Telecommunications
- Microelectronics

Dept. of Space

- Astronomy and Astrophysics (plasma physics, radio space physics, and cosmology)
- Environmental and Climate research

Dept. of Agriculture

- Environmental Sciences and Plant Sciences (plant biochemistry and biotechnology) focused on agricultural and food chemistry, agronomy.
- Geophysical research and environmental monitoring

Dept. Scientific and Industrial Research (CSIR)

- Scientific and Industrial Research covers pattern recognition and machine intelligence with focus on production and operational research.
- Food processing technology with focus on dairy products and vegetable oils, and soil contamination / pollution experiments.
- Information technology covers inventory and supply chain management with focus on genetic algorithms.

Dept. of Biotechnology

- Microbiology and Biotechnology cover plant sciences with specific focus on plant genome research and crop evolution, food biotechnology**,** ethnopharmacology, phytotherapy research, medicinal food, toxicology and pharmacology.
- Molecular biology of human genetic disorders, brain research, and development of vaccines for communicable diseases.

Dept. of Atomic Energy

- Nuclear and Particle Physics cover plasma physics and high-energy physics.
- High power laser systems (CO2 lasers, diode lasers, semiconductor lasers, chemical lasers, excimer lasers and high energy/pulsed lasers). Crystal growth and research.
- Synchrotron radiation research (high energy photon sources)
- Solid-state physics, fission/fusion reactor engineering, and nuclear medicine.

4.2 Extended India Research Collaboration Analysis – Thin Film Research

The document clustering results obtained for the SCI/SSCI, EC, and INSPEC databases (Level 4 Clusters) for the period (2005-2006) identified themes or single technology focus areas of India research. An extended research collaboration analysis was performed for select focus areas that appear predominantly across all three databases. The results (total records) for SCI/SSCI (Cluster {499}), EC (Clusters {310, 361}) and INSPEC (Cluster {199}) indicate that solid thin films is one viable single technology focus area that warrants extended research collaboration analyses. The total combined records assigned to the thin film cluster groupings for each database were as follows:

1. SCI/SSCI Clusters {499}: 4,806 records (10.2 % of 46,819 total records)
2. EC Clusters {310, 361}: 918 records (3.9% of 23,584 records)
3. INSPEC Cluster {199}: 1,091 records (5.8 % of 18,851 total records)

Therefore, a generalized single technology query was developed to retrieve the maximum number of records from each database in order to conduct extended India research collaboration analyses focused on solid thin films. Specifically, the analyses are focused on India thin film research collaboration with the United States (USA) and Peoples Republic of China based on co-authorship.

The specific questions the thin film collaboration analyses attempts to answer or address include:

1. *What are the overall publication and associated trends over the extended timeframe (1980-2006)?*

2. *What is the extent (scope) of India thin film research in terms of overall output production (total articles published) over the extended time frame (1980-2006)?*

3. *What is the extent (scope) of India thin film research collaboration (based on co-authorship) with both the USA and China?*

4. *What other Countries are primary collaborators?*

5. *What Sources (Journals or Conference Proceedings) is the research being published?*

6. *What is the utility of the collaborative research based on article citations and associated Journal impact factors?*

7. *Where is the collaborative research being performed (author affiliations - institutions)?*

8. *What is the overall taxonomy of India thin film research in terms of generalized (broad) subject categories?*

9. *Are the present data mining tools and resources (workstation and database levels) used within the present study adequate to produce useful information from a realm of data, and provide the required fidelity to formulate meaningful conclusions?*

The analyses comprise gross bibliometrics for all primary collaborating countries, prominent journals, author affiliations, and thin film subject categories. The analyses also comprise detailed article publication and citation trend analyses for the period (2005-2006) and for the extended period (1980-2005) by intervals. The following three sections provide the results of the thin film collaboration analyses for the SCI/SSCI, EC and INSPEC databases, respectively. The respective analyses are based on a generalized Boolean search query with combined Topic (thin films) "AND" Author Country Address search term(s) of the form:

- TS/TO* = (Topic Search Term(s)) AND CU/CO* = (Author Country Address Search Term(s)) where:

- TS/TO* = (film* OR "thin-film*" OR "thin film*" OR (deposition AND (arc OR plasma OR "glow discharge" OR "chemical bath" OR "physical vapo$r" OR "ion bombardment" OR "pulsed laser" OR "chemical-vapo$r" OR electrochemical OR evaporative OR "aerosol jet")) OR electrodeposition OR (plasma AND ("electrolytic oxidation" OR spray* OR sputter*)) OR "molecular beam epitaxy" OR topotaxy OR "sol-gel" OR "spin coat*" OR "cathodic arc evaporation" OR anodiz* OR "ion implantation" OR coating* OR electroplat* OR "laser alloy*" OR "magnetron sputter*" OR "wire arc spray*" OR ("vapo$r phase" AND (growth OR nucleation)) OR superlattice* OR "quantum dot" OR nanotube* OR fullerene* OR "monte carlo" OR "molecular dynamic*" OR photovoltaic* OR "solar-cell*" OR (silicon AND (amorphous OR polycrystal* OR nanocrystal*)))

- CU/CO* = One of five Author Country Address search terms as follows:

    1. INDIA
    2. USA
    3. CHINA
    4. INDIA AND USA NOT CHINA (SCI/SSCI Only)
    5. INDIA AND CHINA NOT USA (SCI/SSCI Only)

The Topic search terms were derived from detailed analysis of the document clustering results, with specific focus on themes, keywords, technical phrases, article titles (leaf clusters) and journal information produced by the CLUTO clustering algorithm. The expanded thin film query given above includes select terms that are primarily associated with large substrate thin film deposition processes, and limited specific materials such as including amorphous silicon and crystalline silicon used in semiconductor applications. It should be noted that the Boolean Author Country Address search terms (4 and 5) were used only in the SCI/SSCI analysis since the EC and INSPEC database Author Address fields are single-valued and do not allow Boolean search operators (e.g., AND, NOT, etc.).

* TS/CU combination is used for the SCI/SSCI database.
TO/CO combination is used for both the EC and INSPEC databases.

4.2.1 SCI/SSCI Thin Film Collaboration Analyses

The SCI/SSCI collaboration analysis was conducted using the expanded thin film INDIA (Address 1) query for the period (2005-2006). The query retrieved 4,429 total records and the gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (INDIA):

- USA (260), Germany (167), Japan (166), South Korea (156), France (115), Taiwan (75), England (57), Peoples R China (49), Switzerland (44), and Italy (41)

Top 10 Sources (journals):

- 856 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 2.223
- None of the Top 10 Journals are Indian Journals

Top 10 Author Affiliations:

- 2,205 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- All of the Top 10 affiliations are Indian affiliations (India address)

Top 10 Subject Categories:

- 4,892 total articles are classified in the Top 10 subject categories
- Materials Science, Physics, Physical Chemistry, Coatings and Films and Electrochemistry are the predominant generalized subject categories

A comparative analysis was conducted using the expanded thin film USA (Address 2) query that retrieved 32,172 articles, compared to INDIA with 4,429 articles. The gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (USA):

- Germany (1403), Peoples R China (1079), England (881), South Korea (874), Japan (862), France (775), Canada (667), Italy, (561), Russia (494), and Spain (380)
- INDIA (260) was listed as Country number 16

Top 10 Sources (journals):

- 9,180 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 4.947
- All of the Top 10 Journals are USA Journals

Top 10 Author Affiliations:

- 7,206 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- All of the Top 10 affiliations are USA affiliations (USA address)

Top 10 Subject Categories:

- 30,708 total articles are classified in the Top 10 subject categories
- Physics, Materials Science, Physical Chemistry, Electrical and Electronic Engineering, and Nano-science and Nanotechnology are the predominant generalized subject categories

A comparative analysis was conducted using the expanded thin film CHINA (Address 3) query that retrieved 20,521 articles, compared to USA with 32,172 articles, and INDIA with 4, 429 articles. The gross collaboration bibliometrics for the query indicate the following:

Top 10 Countries Listed with (CHINA):

- USA (1079), Japan (628), Germany (360), Singapore (250), England (224), Australia (194), South Korea (193), France (185), Canada (170), and Taiwan (119)
- INDIA (49) was listed as Country number 16

Top 10 Sources (journals):

- 4,529 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 2.213
- 3 of the Top 10 Journals are Chinese Journals (remainder USA)

Top 10 Author Affiliations:

- 11,854 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- All of the Top 10 affiliations are Chinese affiliations (Peoples R China address)

Top 10 Subject Categories:

- 22,420 total articles are classified in the Top 10 subject categories
- Materials Science, Physics, Physical Chemistry, Metallurgy and Metallurgical Engineering, Polymer Science, and Coatings and Films are the predominant generalized subject categories

It should be noted that the SCI/SSCI Author Country Address search field is a multi-valued field that list multiple countries for each retrieved article. The use of the expanded thin film query with INDIA, USA or CHINA search terms retrieves all articles with the specific address and may include other affiliated Country addresses. Therefore, to further separate the thin film bibliometrics regarding USA and CHINA collaboration with INDIA, similar comparative analyses were conducted using the expanded thin film query with the Boolean Author Country Address search terms (Addresses 4 and 5 above).

The expanded thin film INDIA AND USA NOT CHINA (Address 4) query retrieved 243 articles. The gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (INDIA AND USA NOT CHINA):

- France (8), Germany (6), Greece (6), England (5), Taiwan (5), Australia (4), Canada (4), Italy (4), Japan (3) and Mexico (3)

Top 10 Sources (journals):

- 78 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 3.213
- None of the Top 10 Journals are Indian Journals

Top 10 Author Affiliations:

- 163 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields
- 7 of the Top 10 affiliations are Indian affiliations (India address)
- 137 (84%) total articles are attributed to the Top 7 Indian affiliations

Top 10 Subject Categories:

- 236 total articles are classified in the Top 10 subject categories
- Physics, Materials Science, Physical Chemistry, Polymer Science, Coatings and Films, and Nano-science and Nanotechnology are the predominant generalized subject categories

The expanded thin film query INDIA AND CHINA NOT USA (Address 5) retrieved 32 articles. The gross collaboration bibliometrics indicate the following:

Top 7 Countries Listed with (INDIA AND CHINA NOT USA):

- Japan (4), Egypt (2), Germany (2), Belgium (1), France (1), Singapore (1), and South Korea (1)

Top 10 Sources (journals):

- 12 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 2.429
- One of the Top 10 Journals is an Indian Journal

Top 10 Author Affiliations:

- 36 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- 4 of the Top 10 affiliations are Indian affiliations (India address)
- 13 (36%) total articles are attributed to the Top 4 Indian affiliations

Top 10 Subject Categories:

- 44 total articles are classified in the Top 10 subject categories
- Physics, Materials Science, Electrical and Electronic Engineering, Physical Chemistry, Electrochemistry, and Coatings and Films are the predominant generalized subject categories

In addition to the above gross bibliometric analyses presented above; detailed article publication and citation analyses for the period (2005-2006) were performed. Table 26 provides the results of the analyses for each of the five expanded thin film queries listed above. The highlighted unavailable data is associated with record retrievals greater than 10,000 records, for which, citation reports are not issued by the SCI/SSCI database Analyst Tools.

TABLE 26. SCI/SSCI (2005-2006) COUNTRY ADDRESS BIBLIOMETRICS COMPARISON (THIN FILM QUERY)

Bibliometrics / Country Address	INDIA	USA	CHINA	INDIA AND USA NOT CHINA	INDIA AND CHINA NOT USA
Total Articles (2005-2006)	4,429	32,172	20,521	243	32
Total Articles Published in Top 10 Journals	856	9,180	4,529	78	12
Total Citations*	5,428	NA >10,000	NA >10,000	550	33
Total Citations (Top 1% Articles)*	761	12,361	4,419	95	8
Median Citation (Top 1% Articles)*	14	33	19	25	8
Median Citation (Top 5% Articles)*	7	16	10	13	6.5
Median Citation (Top 10 Articles)*	25	113	51	16	3
Average Cites per Article*	1.23	NA >10,000	NA >10,000	2.26	1.03

Figure 60 graphically illustrates select results from Table 26 including total and median article citations for the Top 1% and 5% of the total number of articles, and for the Top 10 cited articles for the period (2005-2006).

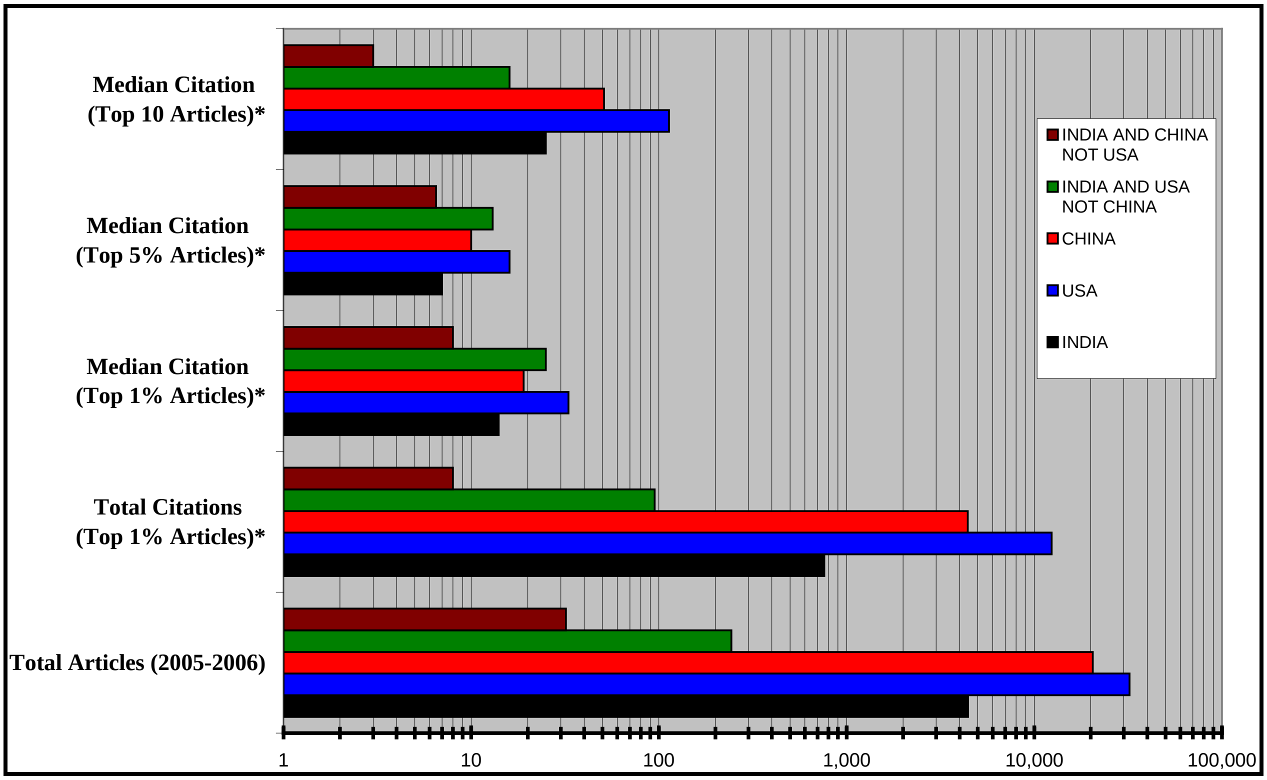

Figure 60. SCI/SSCI (2005-2006) Country Address Bibliometrics Comparison (Thin Film Query)

Figure 60 illustrates several important factors worth noting:

- *USA has a significantly greater output production (published articles) compared to India than China.*

- *USA and China have comparable output production (published articles), however China has a significantly decrease in total and median citations.*

- *The median citations of the Top 1% and Top 5% of the total articles is significantly greater for articles with INDIA AND USA author addresses compared to articles with INDIA only; and similarly comparable for the Top 10 articles. This suggests that collaborative research with USA authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to research being published with only India authors. Note that Table 26 indicates the average cites per article with INDIA AND USA author addresses (2.26), is almost twice that of INDIA author addresses (1.23).*

- *The Top 10 Journals containing articles with INDIA addresses account for 19% of the total articles. The Top 10 Journals containing articles with INDIA AND USA NOT CHINA addresses account for 32% of the total articles. The Top 10 Journals containing articles with INDIA AND CHINA NOT USA addresses account for 38% of the total articles. This again suggests that collaborative research with USA or CHINA is being published in a narrower group of high quality, highly cited Journals; as compared to indigenous research with only India authors that appears to be published in a broader group of journals with varying citations and impact factors.*

It should be noted that the Boolean operators (inclusive AND, and exclusive NOT) that combine INDIA, USA and CHINA in the address queries analyzed above do not preclude other possible affiliated Country addresses. For example, the (INDIA AND USA NOT CHINA) query retrieves all research articles with both INDIA and USA addresses; however, other affiliated country addresses can also be included. The query ONLY excludes CHINA addresses.

To gain a further perspective into the individual thin film collaboration between the USA and CHINA with INDIA, detailed article publication and citation analyses were performed for the period (1980-2005) by intervals and (2005-2006). The analyses establish comparative trends by using the expanded thin film and INDIA address query for each of the listed intervals (80-85, 85-90, etc.). The SCI/SSCI Analyst Tool was then used to select all articles containing INDIA, INDIA with USA, and INDIA with CHINA, *while excluding all other listed affiliated Country addresses*. As such, the analysis presented in the following paragraphs focuses on INDIA thin film collaboration between the USA and CHINA ONLY.

Table 27 provides a listing of the overall publication trend for the first query (expanded thin film and INDIA query) including articles published in the Top 10 journals and average Journal IF for the entire period (1980-2006) by intervals. Table 27 was generated for comparison (refer below to Table 31) to both EC and INSPEC publication trends.

TABLE 27. SCI/SSCI (1980-2006) PUBLICATION AND JOURNAL IMPACT FACTOR TRENDS (THIN FILM AND INDIA QUERY)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	1024	1286	3,447	5,651	8,789	4,429
Top 10 Journal Records	482	566	945	1286	1690	856
Ratio (Top 10 Journal Records / Total Records)	47.07%	44.01%	27.42%	22.76%	19.23%	19.33%
Average Top 10 Journal IF	1.362	1.614	1.705	1.664	1.811	2.223

The results of the complete detailed analysis are summarized in Table 28 that includes publication (total records), citation (median and average) and Journal IF bibliometrics for all articles retrieved using INDIA, INDIA with USA, and INDIA with CHINA addresses. Note for comparison that the first row listed in Table 28 contains the total record retrieved from the

SCI/SSCI database using INDIA (ONLY) as the Author Country address term with NO Topic (e.g., thin films) search term(s). Figure 61 illustrates select results from Table 28 including total articles published for the expanded INDIA query, and the INDIA (ONLY) query (for comparison). Article citations are shown for the total number of articles, Top 1%, and Top 5% of the total number of articles retrieved. Figure 62 illustrates the respective article citation ratios and overall publication trend.

TABLE 28. SCI / SSCI (1980-2006) COUNTRY COLLABORATION
(ARTICLE PUBLICATION AND CITATION TREND COMPARISON)

Bibliometrics / Time Period	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2006
X = Total Articles (India ONLY)	64600	67416	73202	92909	100000	52047
Total Articles (India AND Thin Film Query)	1024	1286	3,447	5,651	8,789	4,429
Total Articles with USA	9	19	168	406	598	260
Total Articles with China	0	0	26	107	127	49
Total Citations* (India AND Thin Film Query)	7871	8570	28,152	45,807	44,116	5,428
Total Citations* with USA	142	300	3140	7221	5421	597
Total Citations* with China	0	0	650	1722	1018	80
Median Citation (Top 10 Articles)* (India AND Thin Film Query)	113	63	121	151	117	25
Median Citation (Top 10 Articles)* with USA	7	26	82	134	74	15
Median Citation (Top 10 Articles)* with China	0	0	36	40	30	5
Average Cites per Article* (India AND Thin Film Query)	7.69	6.66	8.17	8.11	5.02	1.23
Average Cites per Article* with USA	15.78	15.79	18.69	17.79	9.07	2.30
Average Cites per Article* with China	0	0	25.00	16.09	8.02	1.63
Average Top 10 Journal IF (India AND Thin Film Query)	1.362	1.614	1.705	1.664	1.811	2.223
Average Top 10 Journal IF with USA	1.643	1.645	1.732	2.151	2.265	1.923
Average Top 10 Journal IF with China	0	0	2.835	1.249	1.925	1.191

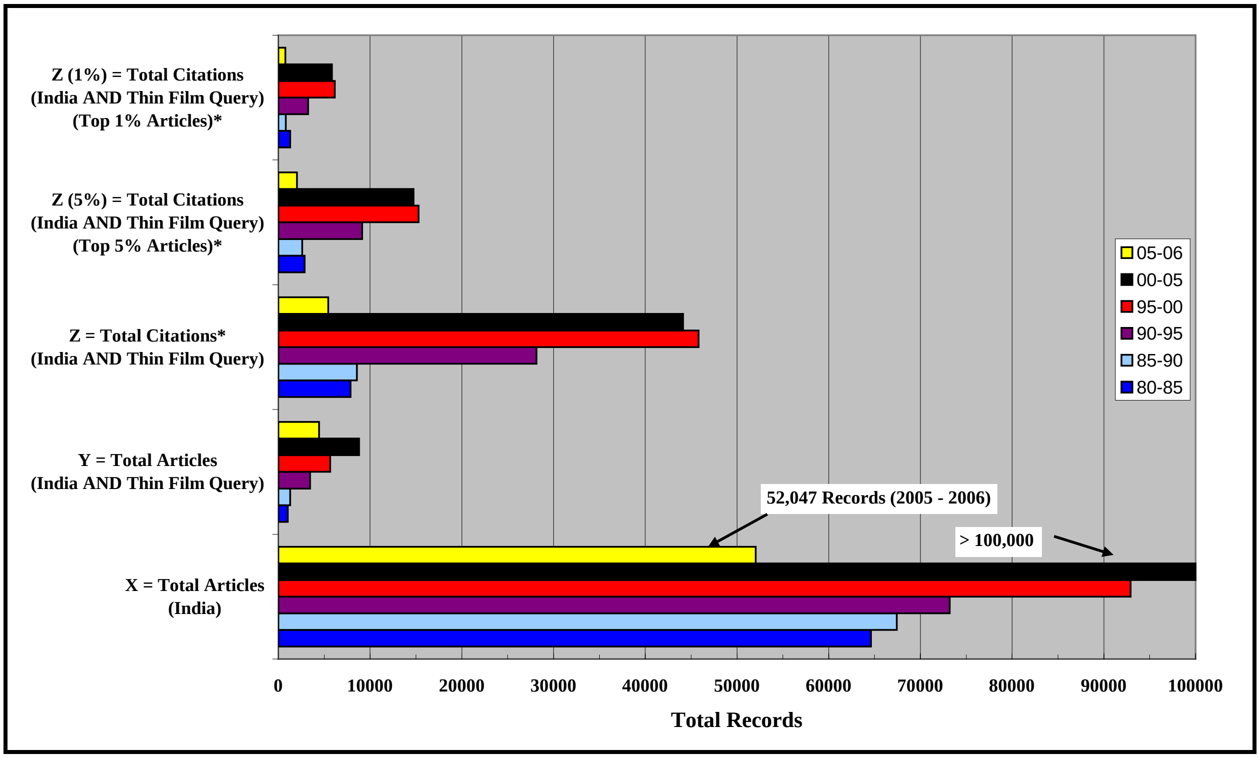

Figure 61. SCI/SSCI (1980-2006) Publication and Citation Trend Comparison (Thin Film AND INDIA Query)

Figure 61 illustrates several important factors worth noting:

- *The total articles retrieved using the (Thin Film and India) query shows a steady publication growth rate during the entire period (1980-2006).*
- *The total citations for articles retrieved using the (Thin Film and India) query shows a steady growth rate during the period (1980-2000). After this period (2000-2005), the total citations decrease.*
- *The trends for total citations of the Top 1% and Top 5% of the most cited articles are identical to the trend for total citations of ALL articles.*
- *The highlighted total articles for the India address (ONLY) query (52,047) records during the period (2005-2006) forms the basis for the present study and is included for comparison.*

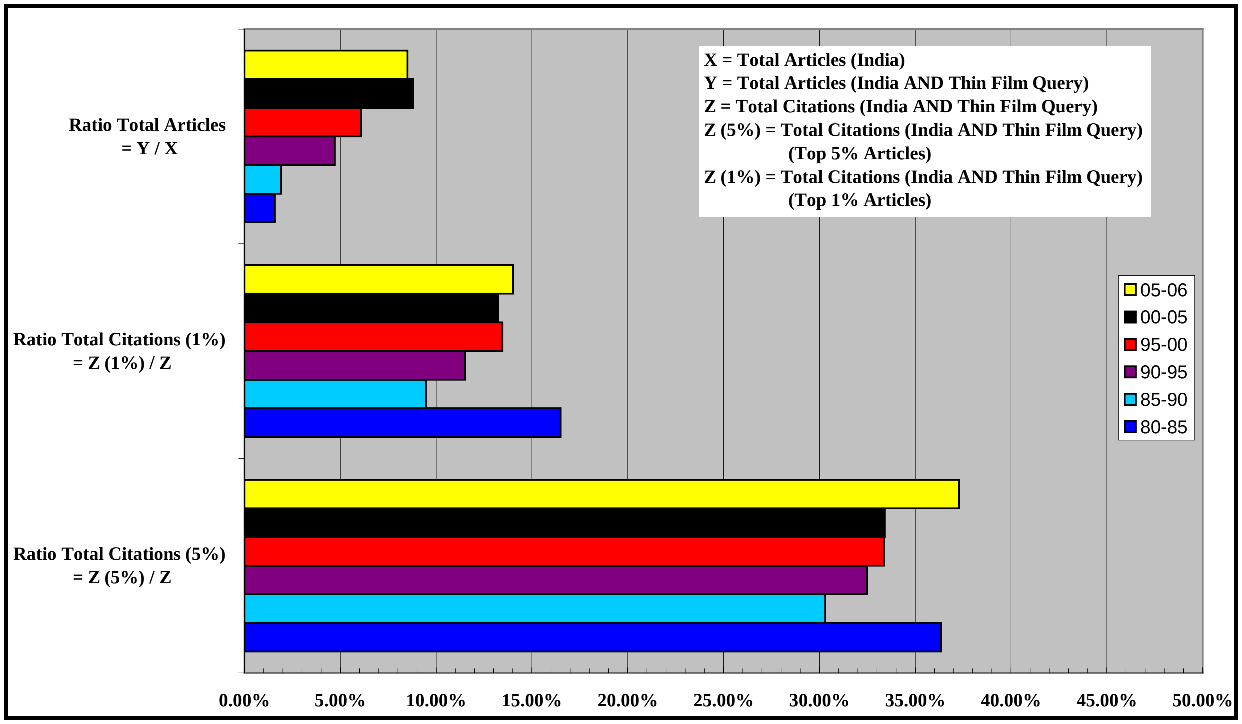

Figure 62. SCI/SSCI (1980-2006) Publication and Citation Ratio Trend (Thin Film AND INDIA Query)

Figure 62 illustrates several important factors worth noting:

- *The ratio of total articles retrieved using the Thin Film and India query to total articles retrieved using the India address (ONLY) query shows a steady increase for the entire period (1980-2005). Note that the similar ratio for (2005-2006) already approximates the ratio for (2000-2005), and it is anticipated to exhibit steady growth in overall percentage of articles for the future period (2007-2010).*
- *This publication trend is also exhibited in the EC and INSPEC collaboration analysis results and supports the finding (clustering results) that thin films is a predominant focus area of India research that is being published and cited in all three databases (refer below to Table 31). This trend also supports the selection to include the topic of thin films within the present collaboration analysis.*
- *The ratio of total citations for the Top 1% and Top 5% of articles retrieved using the Thin Film and India query to total citations shows a dramatic growth rate for the period (2005-2006). During this period, 4,429 total articles were retrieved with 5,428 total citations through 2007. The citation rate for the Top 1% and Top 5% of these articles is extremely high in comparison to the entire preceding period (1980-2005).*
- *During the period (1980-1985), there were 1,024 articles retrieved using the India and Thin Film query with 7,781 total current citations through 2007. The citation ratios for the Top 1% (10) and Top 5% (51) cited articles are large in relative percentages indicating these relatively small fractions of articles have had continuously high citation rates.*

Figure 63 graphically illustrates on a logarithmic scale the publication and citation trend comparison that includes total articles and citations for the expanded thin film AND INDIA, INDIA with USA or INDIA with CHINA queries with all other countries excluded using the Analyst Tool. Also included are the total articles published in the period (1980-2006) for the INDIA (ONLY) query (for comparison). Figure 64 shows the respective median citation for the Top 10 cited articles, average cites per article, and the average IF for the Top 10 Journals (logarithmic scale).

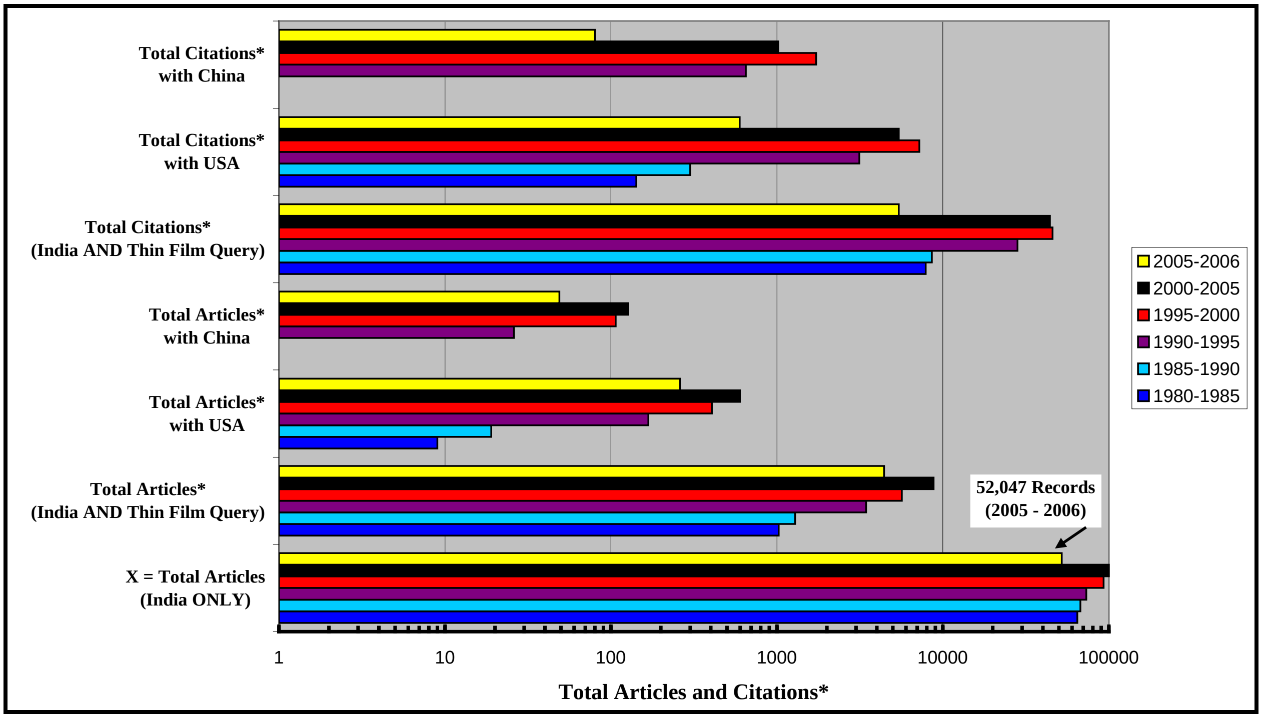

Figure 63. SCI/SSCI (1980-2006) Publication and Citation Trend Comparison (Thin Film with USA or CHINA Query)

Figure 63 illustrates several important factors worth noting:

- *The total articles retrieved using the thin film and India query (with USA and with China) addresses for the period (1990-2006) account for a significant percentage of the total records, when all other listed collaborating countries are considered and their contributing articles tallied. Note that no articles were retrieved for China during the period (1980-1990).*
- *The total articles and citations for (India with USA) always exceed (India with China).*
- *The total articles retrieved using the thin film and India query (with USA and with China addresses) and their relative total citations show a remarkable symmetry, that may be attributed to the relative journals and their associated impact factors, chosen by all three countries for research publication.*
- *This symmetry may not have been identified without the functions of the SCI/SSCI Analyst Tools that proved useful in excluding records from collaborating countries other than USA and China.*

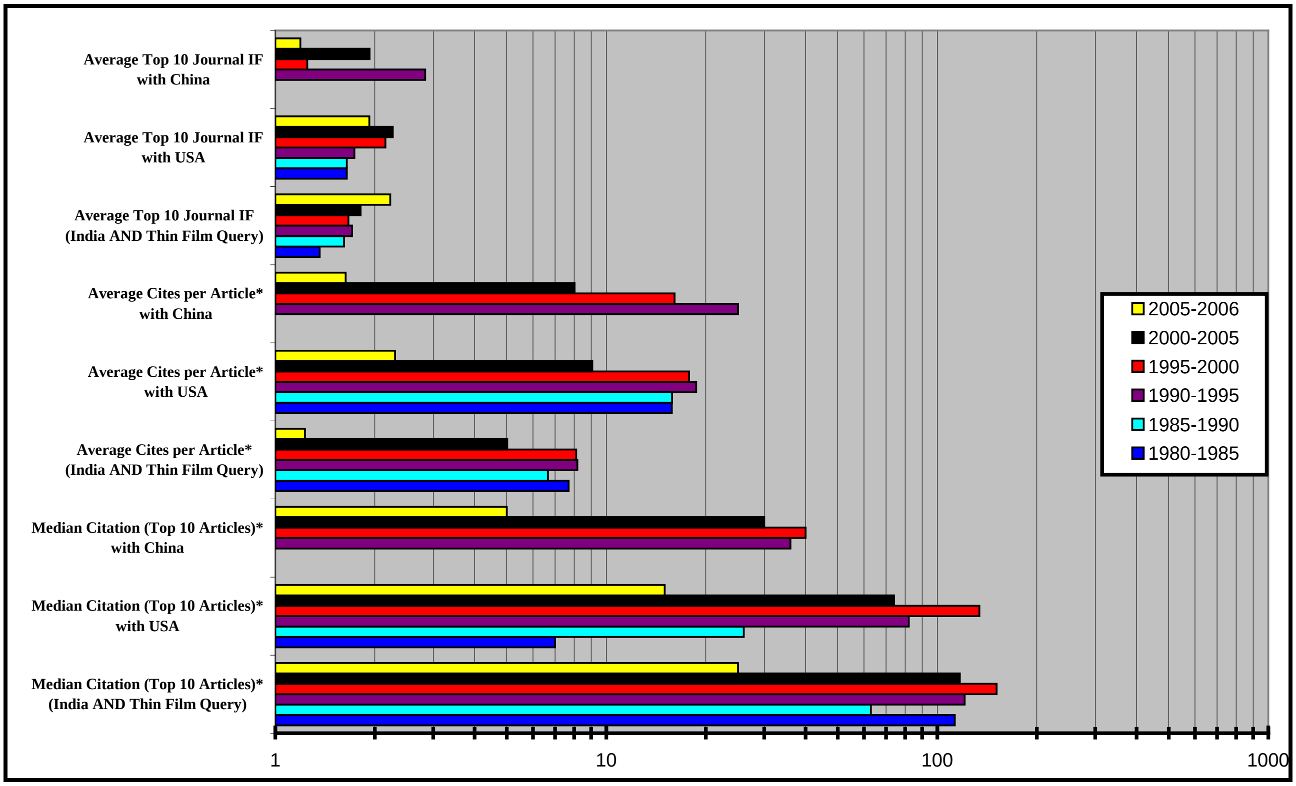

Figure 64. SCI/SSCI (1980-2006) Citation and Journal Impact Factor Trends (Thin Film with USA or CHINA Query)

Figure 64 illustrates several important factors worth noting:

- *The average cites per articles retrieved using the thin film and India query show a significant increase with USA or with China, and all other country addresses excluded. This suggests that India collaborative research with USA or China is being published in highly cited journals outside India, as evidenced by the average Top 10 Journal impact factors (IF) for all three countries.*
- *Note the thin film and India query retrieves all articles with India author addresses, and may include the USA, China and other collaborating countries. The average Top 10 Journal IF for these articles shows a steady increase for the entire period (1980-2006).*

Lastly, Figure 65 illustrates on a Log-Log scale the SCI/SSCI actual total publication and citation trends by individual years for the entire period 1980-2006 using the India address (ONLY) and the expanded thin film AND INDIA address queries. Citation data for the India address (ONLY) articles was unavailable since the number of records exceeded 10,000.

Figure 65 is provided for comparison since previously illustrated bibliometric trends were based on relative defined intervals (e.g. 80-85, 85-90, 90-95, etc.) that contain some overlap of publication and citation data. It should be noted that the relative intervals were used to allow gross comparison of total publication and additional bibliometric trend data including author country addresses that are listed with India in retrieved research articles, journals and impact factors, author affiliations, and thin film subject categories over the entire period (1980-2005). The use of relative intervals also allowed detailed article citation trend analyses over the extended period (1980-2005), as it was not feasible to process this amount of citation data for each individual year over the entire period (1980-2005). The difference between the relative interval and actual individual year trends (due to overlap or record duplications) for total publications equals 2,120 total articles or approximately 11.7% of the total (18,077) actual articles. The difference between the relative interval and actual individual year trends for total citations equals 16,498 total citations or approximately 13.9% of the total (118,018) actual citations. Since all database publication data is dynamic in nature (total articles and citations change daily), the interval trends that were established and used consistently throughout the present study were intended for relative analyses only, not to provide actual data.

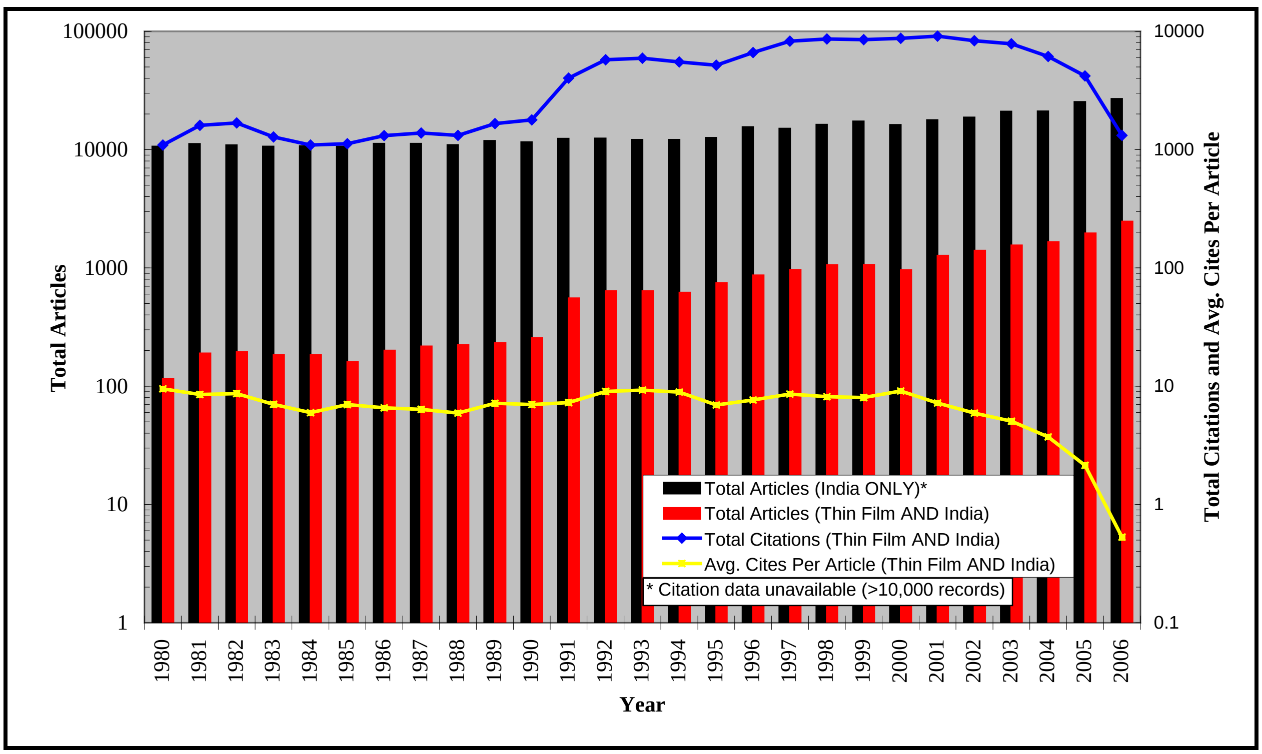

Figure 65. SCI/SSCI Publication and Citation Trends by Individual Years (1980-2006)
(Thin Film AND INDIA Query)

Figure 65 illustrates several important factors worth noting:

- The total output or publications per year using the India address (ONLY) query essentially remained constant for the entire period, while the output for the Thin Film AND India query exhibits steady growth.
- The total citations and average cites per article retrieved using the Thin Film AND India query have steadily decreased since 2001. These trends are also illustrated, although not as pronounced, in Table 28 and Figure 61 given above, which reflect the data by intervals over the same period.

4.2.2 Engineering Compendex (EC) Thin Film Collaboration Analyses

In order to develop comparative thin film bibliometrics and publication trend analyses for the Engineering Compendex (EC) database, the expanded thin film and INDIA address query was used to retrieve articles for the period (1980-2006). For each time interval (e.g., 80-85, 85-90, 90-95, etc.) the total articles retrieved were compared (by ratio) to the total articles published in the Top 10 Journals. In addition, the average Impact Factor (IF) for the Top 10 Journals was also calculated. Table 29 provides a summary of the EC bibliometric results in the same format as Table 27 above (SCI/SSCI results) for comparison.

Figure 66 illustrates the overall publication trend including the ratio of total articles to Top 10 Journal articles and average IF for each time interval. Note that the EC database contains only one author Country Address for each article; and that the database does not contain similar citation data, as compared to the SCI/SSCI database. Therefore, comparative analysis of article citation data was not performed for the SCI/SSCI and EC databases.

TABLE 29. EC (1980-2006) PUBLICATION AND JOURNAL IMPACT FACTOR TRENDS (THIN FILM AND INDIA QUERY)

Engineering Compendex (EC)	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**
Total Records	**1834**	**2101**	**2193**	**3531**	**6034**	**3004**
Top 10 Journal Records	**662**	**750**	**692**	**1054**	**1394**	**656**
Ratio (Top 10 Journal Records / Total Records)	**0.361**	**0.357**	**0.316**	**0.298**	**0.231**	**0.218**
Average Journal IF	**1.657**	**1.192**	**1.290**	**1.174**	**1.422**	**1.723**

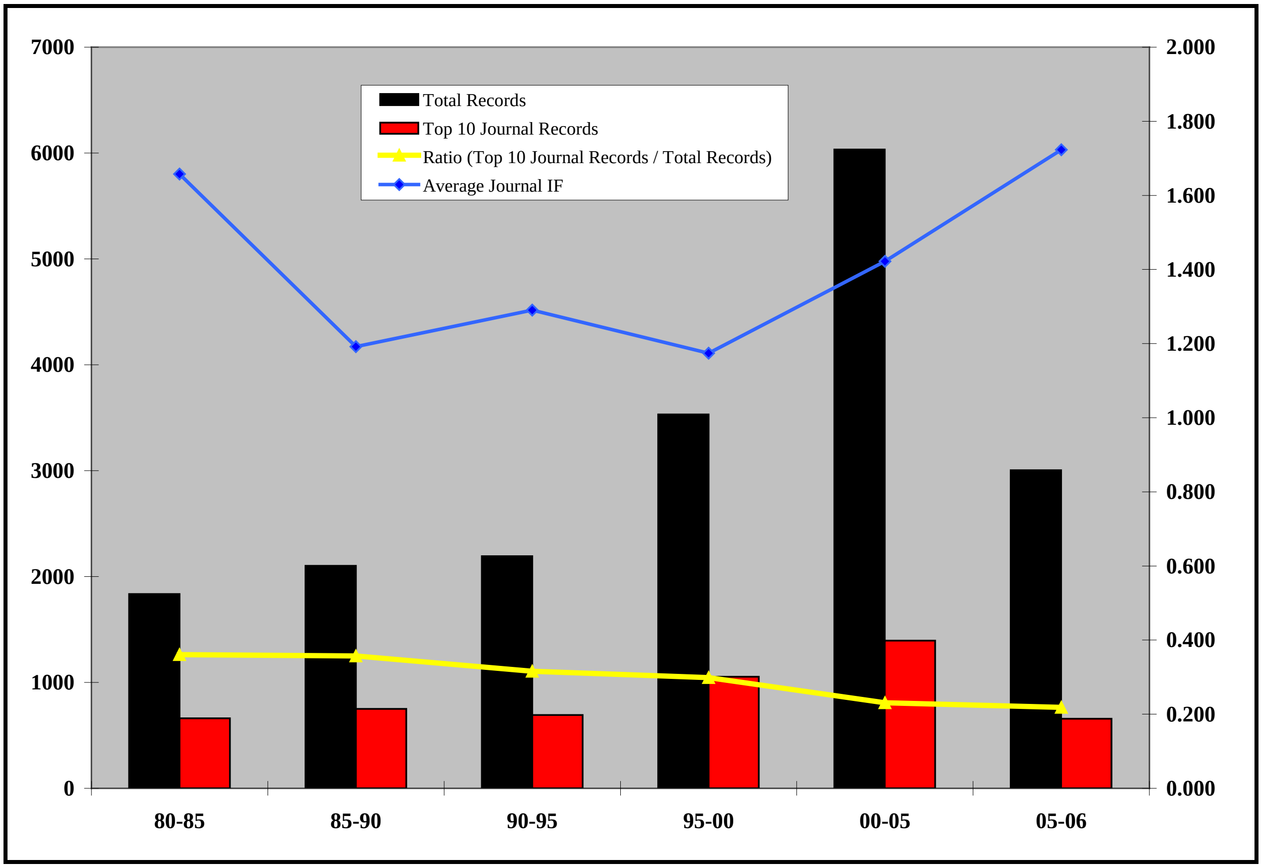

Figure 66. EC (1980-2006) Total Article and Average Top 10 Journal Impact Factors Publication Trends (Thin Film AND INDIA Query)

Figure 66 illustrates several important factors worth noting:

- *The total articles and Top 10 Journal articles show a significant increase for the period (2000-2005) compared to preceding periods (1980-2000).*
- *The average Top 10 Journal IF also shows a significant and steady increase throughout the period (1995-2006).*
- *The ratio of articles published in the Top 10 Journals to total articles is essentially constant throughout the entire period (1980-2006).*

4.2.3 INSPEC Thin Film Collaboration Analyses

In order to develop comparative thin film bibliometrics and publication trend analyses for the INSPEC database, the expanded thin film and INDIA address query was used to retrieve articles for the period (1980-2006). For each time interval (e.g., 80-85, 85-90, 90-95, etc.) the total articles retrieved were compared (by ratio) to the total articles published in the Top 10 Journals. In addition, the average Impact Factor (IF) for the Top 10 Journals was also calculated. Table 30 provides a summary of the bibliometric results in the same format as Table 27 (SCI/SSCI results) and Table 29 (EC results) provided above for comparison.

Figure 67 illustrates the overall publication trend including the ratio of total articles to Top 10 Journal articles and average IF for each time interval. Note that the INSPEC database contains only one author Country Address for each article; and that the database does not contain similar citation data, as compared to the SCI/SSCI database. Therefore, comparative analysis of article citation data was not performed for the SCI/SSCI and INSPEC databases.

TABLE 30. INSPEC (1980-2006) PUBLICATION AND JOURNAL IMPACT FACTOR TRENDS (THIN FILM AND INDIA QUERY)

INSPEC	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	1945	2487	3157	3910	5319	2498
Top 10 Journal Records	761	875	1019	1131	1290	659
Ratio (Top 10 Journal Records / Total Records)	0.39	0.35	0.32	0.29	0.24	0.26
Average Journal IF	0.875	0.976	2.029	2.100	1.738	1.401

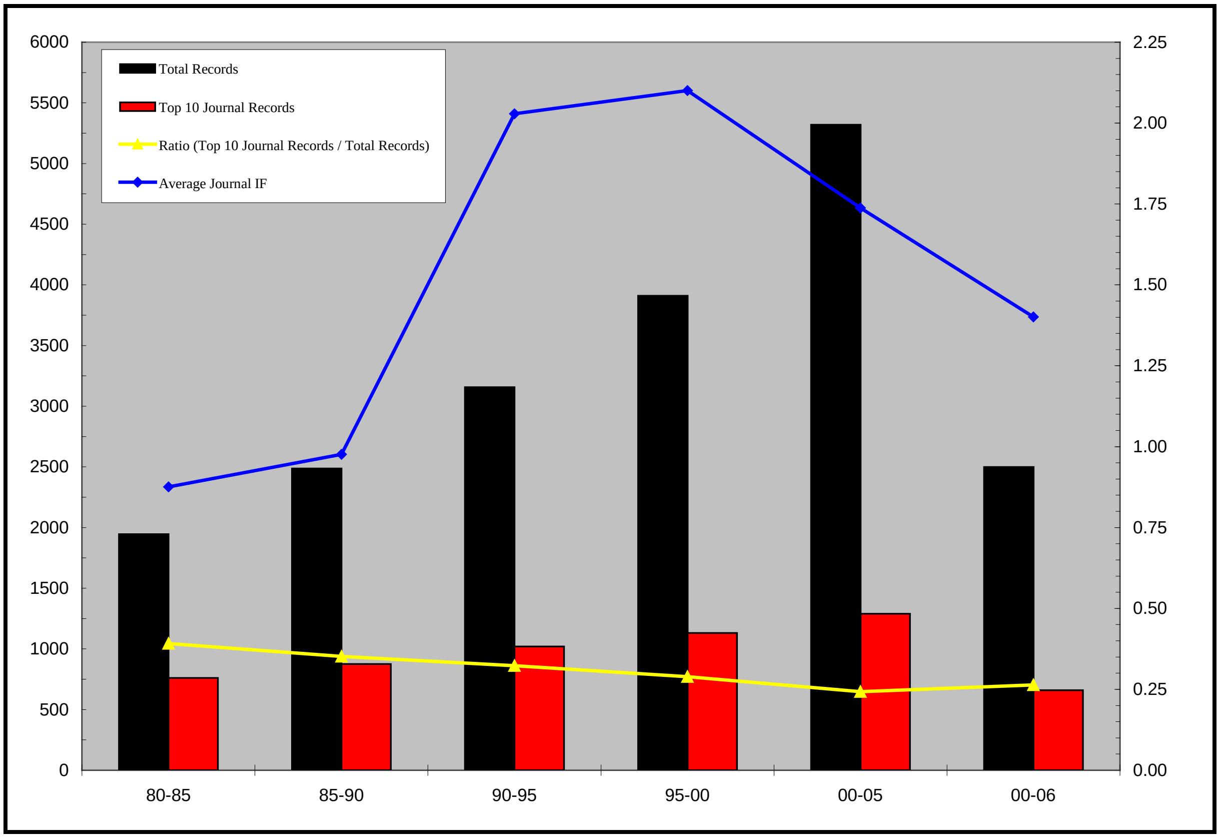

Figure 67. INSPEC (1980-2006) Total Article and Average Top 10 Journal Impact Factors Publication Trends (Thin Film AND INDIA Query)

Figure 67 illustrates several important factors worth noting:

- *The total articles show a significant increase for the period (2000-2005) compared to preceding periods (1980-2000).*
- *The average Top 10 Journal IF shows a significant and steady decrease throughout the period (1995-2006). Note that the EC average Top 10 Journal IF (Figure 200) shows a steady increase for the same period.*
- *The ratio of articles published in the Top 10 Journals to total articles is essentially constant throughout the entire period (1980-2006).*

4.2.4 Comparative Database Thin Film Collaboration Analyses

Table 31 provide a comparative listing of the total articles retrieved using the Thin Film and India query, and total articles retrieved using the India address (ONLY) query from the SCI/SSCI, EC and INSPEC databases for the period (1980-2006). Table 31 also lists the respective ratio of total articles retrieved using the Thin Film and India query and total articles retrieved using the India address (ONLY) query for each database.

TABLE 31. SCI/SSCI, EC AND INSPEC (1980-2006) COMPARATIVE TOTAL PUBLICATION TREND (THIN FILM QUERY AND INDIA) / (INDIA ONLY)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06	80-05
SCI/SSCI Total Records (India ONLY)	64600	67416	73202	92909	100000	52047	398127
SCI/SSCI Total Records (Thin Film AND India)	1024	1286	3,447	5,651	8,789	4,429	20197
SCI/SSCI Total Record Ratio (Thin Film AND India / India)	1.59%	1.91%	4.71%	6.08%	8.79%	8.51%	5.07%
EC	80-85	85-90	90-95	95-00	00-05	05-06	80-05
EC Total Records (India ONLY)	22728	22941	20104	31735	53360	24,475	150868
EC Total Records (Thin Film AND India)	1834	2101	2193	3531	6034	3004	15693
EC Total Record Ratio (Thin Film AND India / India)	8.07%	9.16%	10.91%	11.13%	11.31%	12.27%	10.40%
INSPEC	80-85	85-90	90-95	95-00	00-05	05-06	80-05
INSPEC Total Records (India ONLY)	28506	30606	33246	34612	45056	18988	172026
INSPEC Total Records (Thin Film AND India)	1945	2487	3157	3910	5319	2498	16818
INSPEC Total Record Ratio (Thin Film AND India / India)	6.82%	8.13%	9.50%	11.30%	11.81%	13.16%	9.78%

Figure 68 illustrates the overall publication trends for total articles, and Figure 69 illustrates the respective ratios for each database (including Grand Total for all three databases) for the entire period (1980-2006).

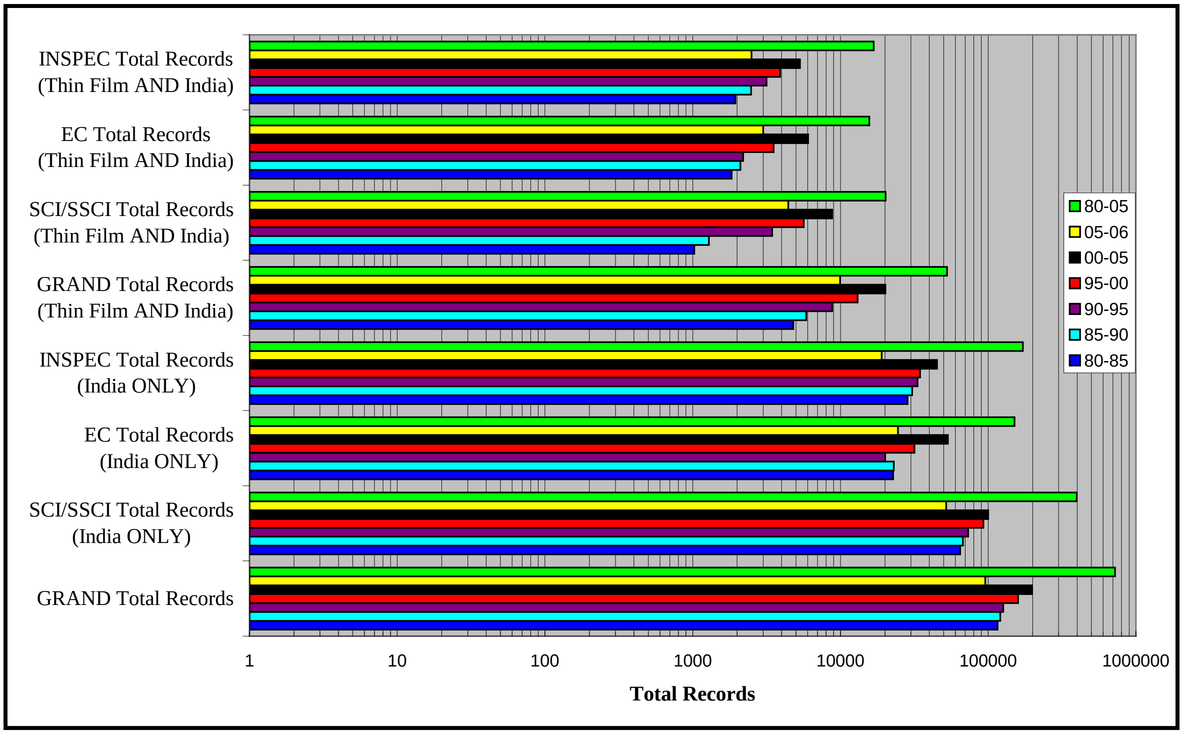

Figure 68. Comparative Total Article Publication Trend (1980-2006)
(Thin Film AND India Query) / (India ONLY)

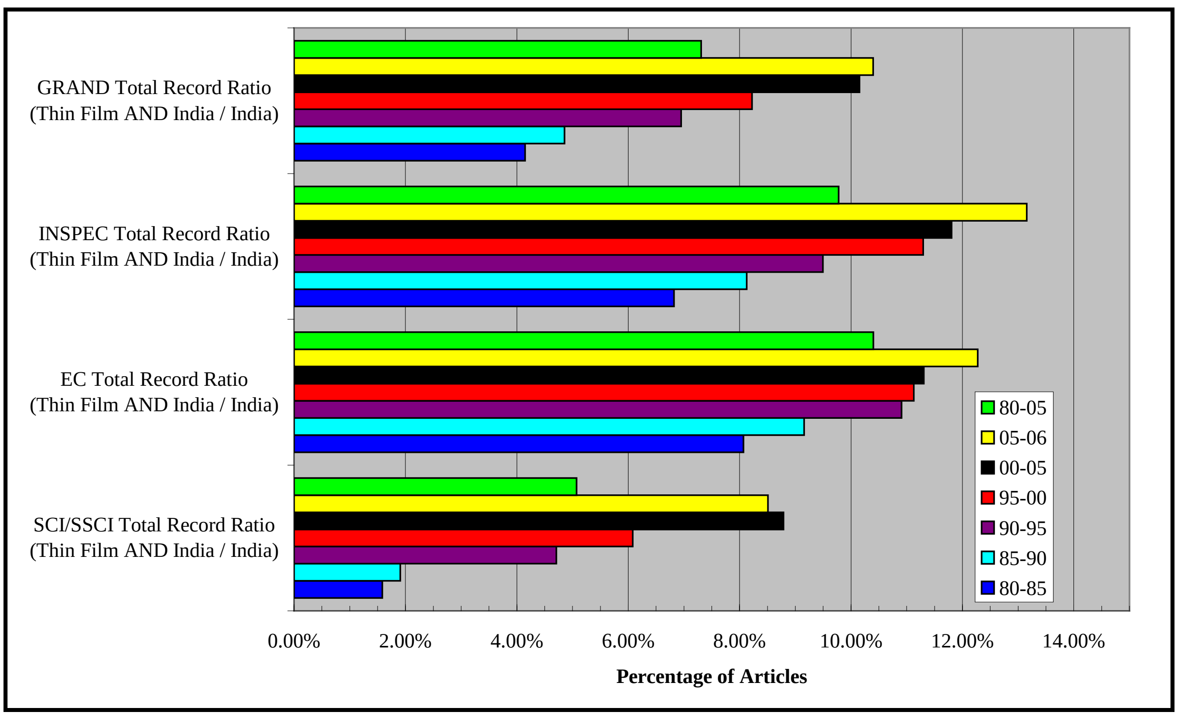

Figure 69. Comparative Total Article Ratio Publication Trend (1980-2006)
(Thin Film AND India Query) / (India ONLY)

Table 32 combines Table 27, Table 29, and Table 30 listed above to provide a comparative listing of the total article publication and average Top 10 Journal IF Trends for the SCI/SSCI, EC and INSPEC databases for the period (1980-2006) using the Thin Film AND INDIA address query. Figure 70 graphically illustrates the overall publication trends for each database.

TABLE 32. COMPARATIVE TOTAL PUBLICATION AND AVERAGE TOP 10 JOURNAL IF TRENDS (SCI/SSCI, EC AND INSPEC (1980-2006)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	1024	1286	3,447	5,651	8,789	4,429
Top 10 Journal Records	482	566	945	1286	1690	856
Ratio (Top 10 Journal Records / Total Records)	47.07%	44.01%	27.42%	22.76%	19.23%	19.33%
Average Top 10 Journal IF	1.362	1.614	1.705	1.664	1.811	2.223
EC	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**
Total Records	1834	2101	2193	3531	6034	3004
Top 10 Journal Records	662	750	692	1054	1394	656
Ratio (Top 10 Journal Records / Total Records)	36.10%	35.70%	31.55%	29.85%	23.10%	21.84%
Average Top 10 Journal IF	1.657	1.192	1.290	1.174	1.422	1.723
INSPEC	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**
Total Records	1945	2487	3157	3910	5319	2498
Top 10 Journal Records	761	875	1019	1131	1290	659
Ratio (Top 10 Journal Records / Total Records)	39.13%	35.18%	32.28%	28.93%	24.25%	26.38%
Average Top 10 Journal IF	0.875	0.976	2.029	2.100	1.738	1.401

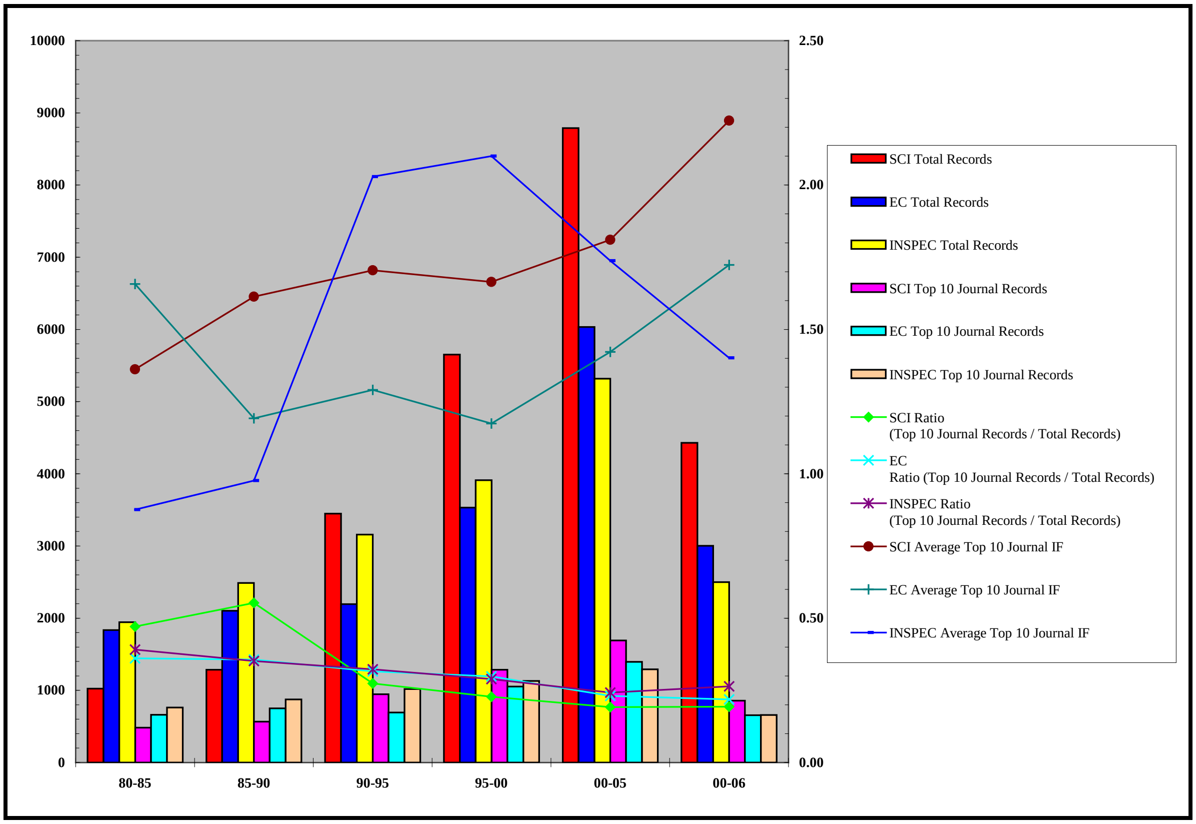

Figure 70. Comparative Total Article and Average Top 10 Journal Impact Factors Publication Trends

Figure 70 illustrates several important factors worth noting:

- *The total articles published in all databases show a significant increase for the period (1980-2005). The total articles published in both the EC and INSPEC databases exceeded the total articles published in SCI/SSCI for the period (1980-1990). After this period, SCI/SSCI total publications show a significant increase and exceed EC and INSPEC total publications.*
- *The average Top 10 Journal IF for the SCI/SSCI and EC article publications show a similar trend that steadily increases for the period (1985-2006). The average Top 10 Journal IF for INSPEC publications shows an opposite trend and steadily decreases throughout the period (1995-2006).*
- *The ratio of articles published in the Top 10 Journals to total records is essentially constant throughout the entire period (1980-2006) for all three databases.*

The articles retrieved using the expanded Thin Film AND INDIA address query from all databases indicate that India is conducting organic and inorganic molecular thin film research primarily focused on semiconductor and photovoltaic applications. The following paragraphs provide author affiliation data for the period (2005-2006) to address what specific research institutions, laboratories, universities or industry are ***currently*** involved in thin film research.

4.2.4.1 SCI/SSCI Database (2005-2006)

The Thin Film AND INDIA address query retrieved 4,429 total articles from the SCI/SSCI database for the period (2005-2006). The Top 25 author affiliations involved in this research are listed in Table 33 and account for approximately 72% (3,197 articles) of the total articles. The Top 10 affiliations account for approximately 50% of the total 4,429 records. Figure 71 shows the SCI/SSCI (2005-2006) auto-correlation map and the respective linkages indicating collaboration between the Top 25 Author Affiliations.

TABLE 33. SCI/SSCI (2005-2006) TOP 25 AUTHOR AFFILIATIONS (THIN FILM AND INDIA)

SCI/SSCI (2005-2006) Top 25 Author Affiliations Thin Film Query AND INDIA	Total Records
INDIAN INST TECHNOL	884
INDIAN INST SCI	307
BHABHA ATOM RES CTR	201
INDIAN ASSOC CULTIVAT SCI	148
NATL CHEM LAB	130
NATL PHYS LAB	121
UNIV DELHI	114
TATA INST FUNDAMENTAL RES	104
JADAVPUR UNIV	99
CENT ELECTROCHEM RES INST	97
CTR NUCL SCI	82
INDIRA GANDHI CTR ATOM RES	81
SHIVAJI UNIV	80
ANNA UNIV	78
ALAGAPPA UNIV	76
INST PHYS	73
COCHIN UNIV SCI & TECHNOL	69
BANARAS HINDU UNIV	67
JAWAHARLAL NEHRU CTR ADV SCI RES	65
SAHA INST NUCL PHYS	58
UNIV POONA	58
INDIAN INST CHEM TECHNOL	54
SOLID STATE PHYS LAB	52
UNIV HYDERABAD	52
UNIV MADRAS	47
Top 25 Affiliation Total Records	3,197
Thin Film Query AND INDIA Total Records	4,429
Percentage of Total Records	72.18%

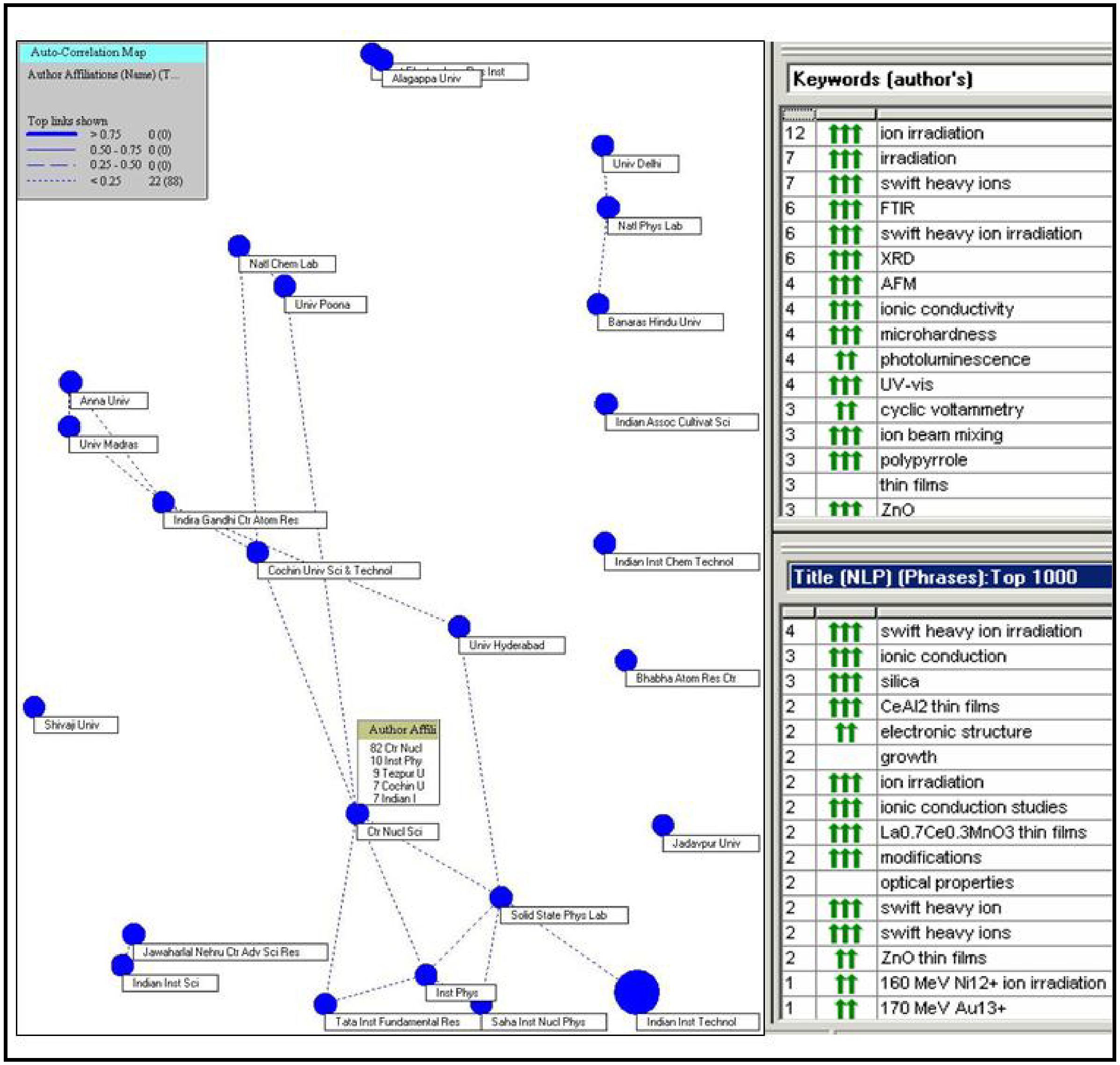

Figure 71. SCI/SSCI (2005-2006) Top 25 Author Affiliations Auto-correlation Map
(Thin Film AND INDIA Query)

The Top 25 author affiliation auto-correlation map shown in Figure 71 depicts moderately connected publishing groupings or intra-connection within four discrete groups. There is also reasonable inter-connection across these groups centered on the following affiliations:

1. Nuclear Science Center (82 records)
2. Solid State Physics Laboratory (51 records)
3. Institute of Physics (73 records)
4. Indira Gandhi Center for Atom Research (81 records)

The Indian Institute of Technology (884 records) was the most prolific producer of research articles (indicated by the large circle) shows only a moderate connection to the Solid State Physics Laboratory (52 records). The second most prolific producer, the Indian Institute of Science (307) shows only a moderate connection to Jawaharlal Nehru Center for Advanced Scientific Research *given the selected threshold connectivity level for displaying linkages.*

4.2.4.2 EC Database (2005-2006)

The Thin Film AND INDIA query retrieved 3,004 total articles from the EC database for the period (2005-2006). The Top 25 Author Affiliations involved in this research are listed in Table 34 and account for approximately 17% (519 articles) of the total articles. The Top 10 affiliations account for approximately 9% of the total 3,004 records. An author-affiliation auto-correlation map was also generated for the EC database records for the period (2005-2006), however; since the EC database provides only one author affiliation per record, the map shows no connected groups or linkages. The EC auto-correlation map is useful however, since information associated with authors, subject categories, keyword and journals can be extracted and compared to SCI/SSCI and INSPEC maps. Figure 72 shows the EC (2005-2006) auto-correlation map for the Top 25 author affiliations.

TABLE 34. EC (2005-2006) TOP 25 AUTHOR AFFILIATIONS (THIN FILM AND INDIA)

EC (2005-2006) Top 25 Author Affiliations Thin Film Query AND INDIA	**Total Records**
Central Electrochemical Research Institute	**44**
Institute Of Physics	**32**
Organic Coatings and Polymers Division, Indian Institute of Chemical Technology	**29**
Department of Physics, Indian Institute of Technology	**28**
Department of Physics, Indian Institute of Science	**27**
National Physical Laboratory	**26**
Department of Chemical Engineering, Indian Institute of Technology	**25**
Surface Engineering Division, National Aerospace Laboratories	**23**
Department of Materials Science, Indian Association for The Cultivation Of Science	**20**
Department of Physics and Astrophysics, University of Delhi	**20**
Metallurgical and Materials Engineering Department, Indian Institute of Technology Roorkee	**19**
Materials Science Centre, Indian Institute of Technology	**19**
Thin Film Physics Laboratory, Department of Physics, Shivaji University	**18**
Surface Physics Division, Saha Institute of Nuclear Physics	**18**
Department of Physics, Cochin University of Science and Technology	**17**
Sol-Gel Division, Central Glass and Ceramic Research Institute	**17**
Materials Research Centre, Indian Institute of Science	**16**
Department of Mechanical Engineering, Indian Institute of Technology	**16**
Nuclear Science Centre	**16**
Department of Chemistry, Indian Institute of Technology	**16**
Thin Film Laboratory, Department of Physics, Indian Institute of Technology Delhi	**15**
Electrochemical Materials Science Division, Central Electrochemical Research Institute	**15**
Solid State Physics Laboratory	**15**
Department of Instrumentation, Indian Institute of Science	**14**
Department of Metallurgy, Indian Institute of Science	**14**
Top 25 Affiliation Total Records	**519**
Thin Film Query AND INDIA Total Records	**3004**
Percentage of Total Records	**17.28%**

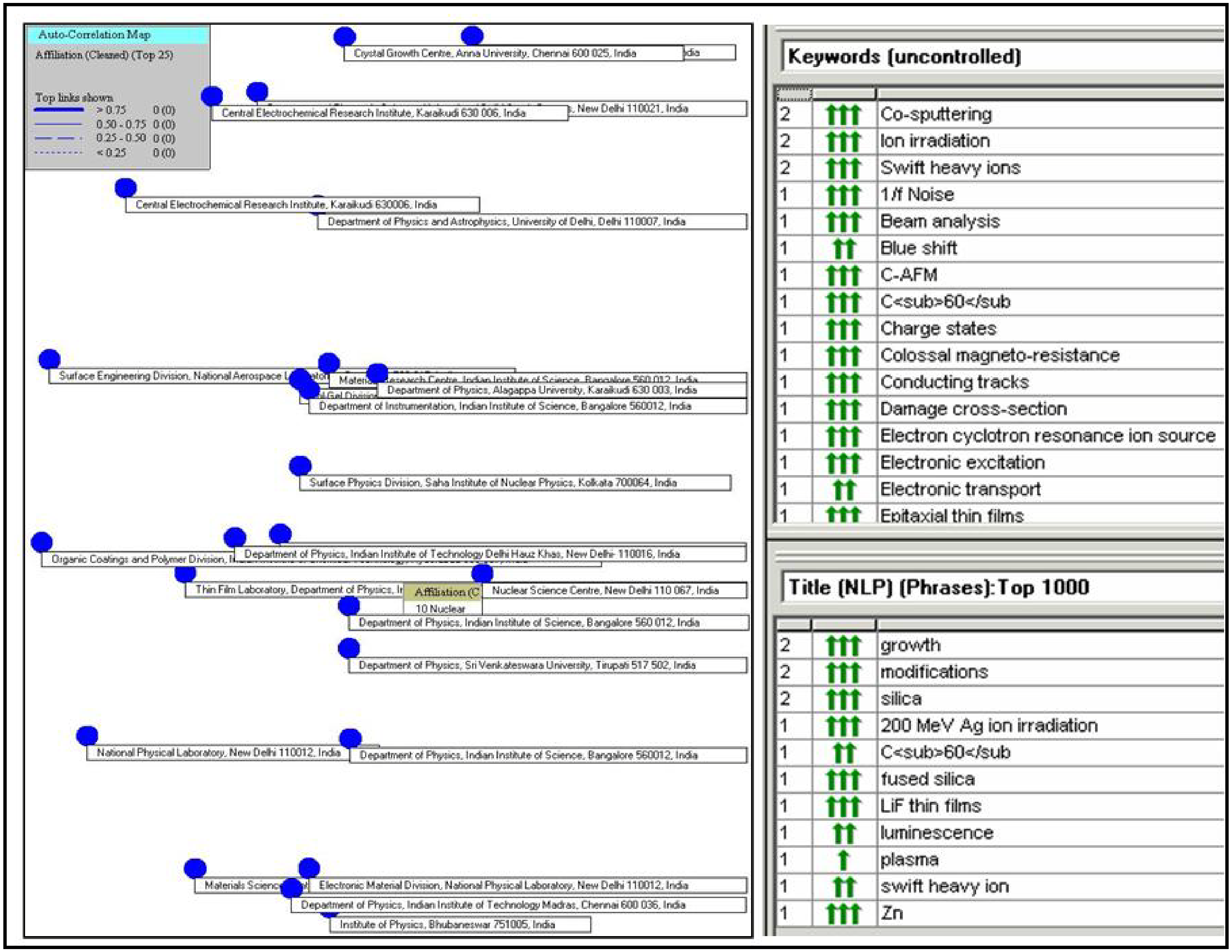

Figure 72. EC (2005-2006) Top 25 Author Affiliations Auto-correlation Map
(Thin Film AND INDIA Query)

4.2.4.3 INSPEC Database (2005-2006)

The Thin Film AND INDIA query retrieved 2,498 total articles from the INSPEC database for the period (2005-2006). The Top 25 Author Affiliations involved in this research are listed in Table 35 and account for approximately 17.5% (436 articles) of the total articles. The Top 10 affiliations account for approximately 9% of the total 2,498 records. An author-affiliation auto-correlation map was also generated for the INSPEC database records for the period (2005-2006), however; since the INSPEC database provides only one author affiliation per record, the map shows no connected groups or linkages. The INSPEC auto-correlation map is useful however, since information associated with authors, subject categories, keyword and journals can be extracted and compared to SCI/SSCI and EC auto-correlation maps. Figure 73 shows the INSPEC (2005-2006) auto-correlation map for the Top 25 author affiliations.

TABLE 35. INSPEC (2005-2006) TOP 25 AUTHOR AFFILIATIONS (THIN FILM AND INDIA)

INSPEC (2005-2006) Top 25 Author Affiliations Thin Film Query AND INDIA	Total Records
Dept. Of Phys., Shivaji Univ., Kolhapur	35
Inst. Of Phys., Bhubaneswar	26
Dept. Of Phys., Indian Inst. Of Sci., Bangalore	25
Dept. Of Phys., Sri Venkateswara Univ., Tirupati	23
Dept. Of Phys., Cochin Univ. Of Sci. Technol.	22
Nat. Phys. Lab., New Delhi	21
Central Electrochem. Res. Inst., Karaikudi	21
Nat. Metall. Lab., Jamshedpur	19
Dept. Of Phys., Indian Inst. Of Technol., New Delhi	19
Dept. Of Phys., Univ. Of Pune	18
Mater. Res. Centre, Indian Inst. Of Sci., Bangalore	17
Dept. Of Phys., Indian Inst. Of Technol. Delhi, New Delhi	17
Nucl. Sci. Centre, New Delhi	17
Surface Eng. Div., Nat. Aerosp. Labs., Bangalore	16
Dept. Of Phys., Alagappa Univ., Karaikudi	14
Mater. Sci. Centre, Indian Inst. Of Technol., Kharagpur	14
Dept. Of Instrum., Indian Inst. Of Sci., Bangalore	14
Dept. Of Metall. Eng. Mater. Sci., Indian Inst. Of Technol., Mumbai	13
Solid State Struct. Chem. Unit, Indian Inst. Of Sci., Bangalore	13
Solid State Phys. Lab., Delhi	13
Dept. Of Phys., Bharathiar Univ., Coimbatore	13
Dept. Of Phys. Astrophys., Univ. Of Delhi	12
Dept. Of Condensed Matter Phys. Mater. Sci., Tata Inst. Of Fundamental Res., Mumbai	12
Dept. Of Phys., Anna Univ., Chennai	11
Dept. Of Chem., Univ. Of Burdwan	11
Top 25 Affiliation Total Records	436
Thin Film Query AND INDIA Total Records	2498
Percentage of Total Records	17.45%

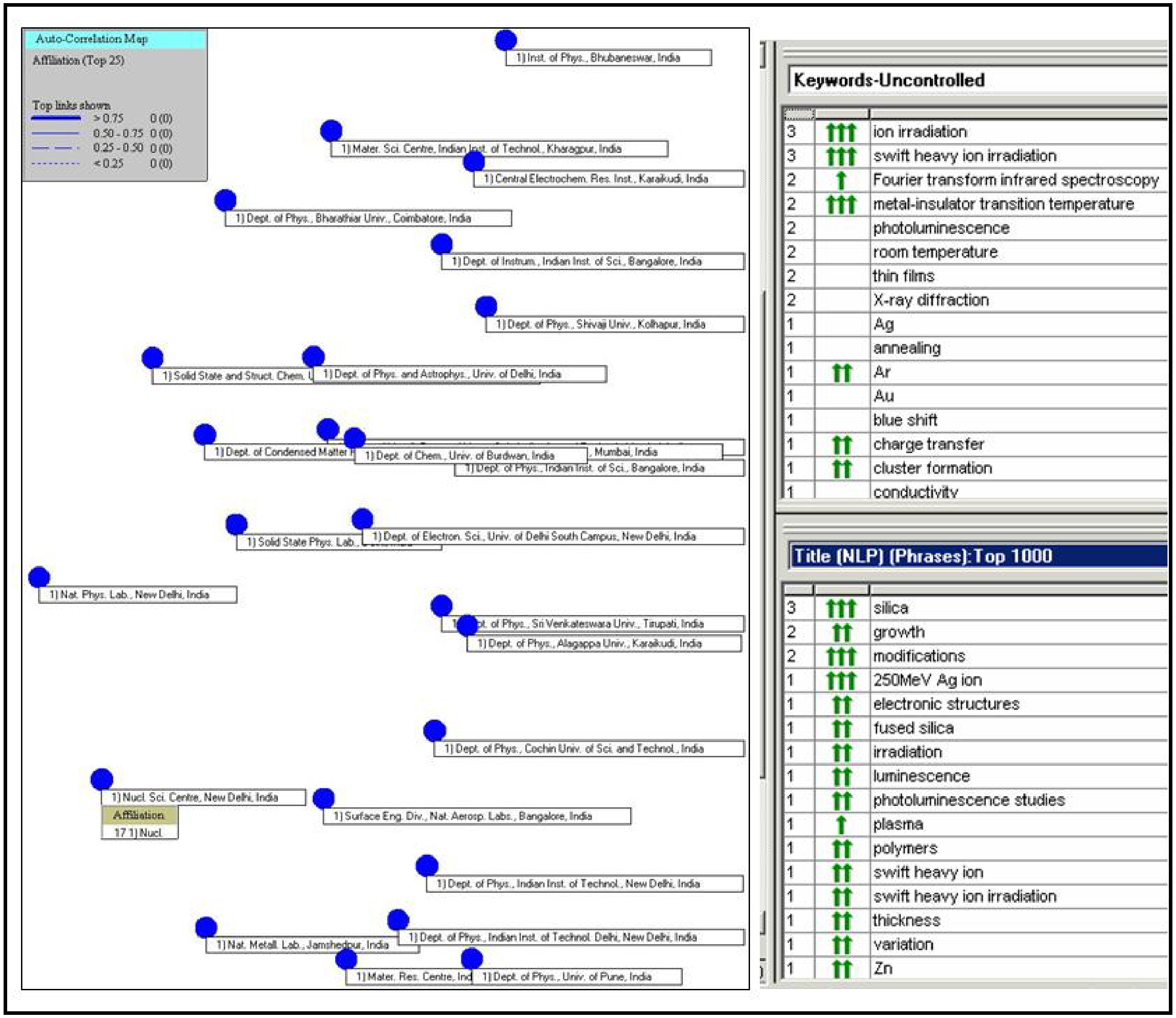

Figure 73. INSPEC (2005-2006) Top 25 Author Affiliations Auto-correlation Map
(Thin Film AND INDIA Query)

As indicated in Figure 71 (SCI/SSCI map), the Nuclear Science Center and Solid State Physics Laboratory show numerous linkages to other major institutions including IIT, Institute of Physics, Tata Institute of Fundamental Research and Saha Institute of Nuclear Physics. As such, these two institutions were selected for further analysis to identify prominent thin film focus areas and publication topics.

Prominent Indian (indigenous) thin film research focus areas and publication topics were identified using two sources of information: 1) Research article titles extracted from author affiliation auto-correlation maps for the Nuclear Science Center and Solid State Physics Laboratory (Figure 17); and 2) Research article titles provided by the CLUTO clustering algorithm for all database taxonomy leaf clusters. All research articles published by the Nuclear Science Center and Solid State Physics Laboratory were retrieved, sorted based on total times cited, and then analyzed to determine principal thin film focus areas. Due to the large number of leaf cluster titles, only a sampling of titles was analyzed in a similar manner. Prominent research focus areas and topics include:

1. Development of fast ion beam sources for engineering the micro- and nanostructural properties of thin films. Focus is on metallic and rare earth ion beams that have important roles in nano-technology and enhancement of optical properties of semiconductor nano-particles inside various matrices.
2. Polycrystalline and nanoparticle thin film formation using vacuum evaporation and inert gas evaporation techniques, respectively.
3. Amorphous thin films formation using thermal evaporation
4. Multilayer heterostructural thin film formation using e-beam evaporation techniques to synthesize metallic contacts for nanoscale devices (nanomixing). Swift ion sources are then used to tailor micro- and nanostructural properties.
5. Conducting polymer polypyrrole thin films electrodeposited on coated glass substrates. The polymer films are irradiated with swift ion sources are then used to tailor micro- and nanostructural properties and increase film conductivity.
6. Thin film formation using sol-gel technique and characterization of structural and dielectric properties using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), AC conductivity techniques.
7. Thin film formation on silicon substrates using pulsed excimer laser ablation techniques. X-ray diffraction and atomic force microscope techniques are used to study the structural characteristics of the films.
8. Epitaxial thin film growth on CdTe and CZT substrates using new asymmetric vapor phase epitaxy (ASVPE) techniques. The epitaxial films are electrically characterized using Hall Effect techniques and capacitance-voltage (C-V) measurements.
9. Thin film formation with ZnO nanocrystals in silica using RF reactive magnetron co-sputter deposition and post-annealing techniques. The films are deposited from a ZnO/Si composite target in radio-frequency (RF) oxygen plasma and annealed in air/vacuum at high temperatures to grow ZnO nanocrystals. The deposited and annealed films are characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), (UV-VIS) spectroscopy and photoluminescence (PL) measurements.

10. Development of fullerenes and modification of material mechanical properties by energetic ion irradiation. Thin film formation of a Si based inorganic polymer with nanocolumns of C clusters using swift ion irradiation tailoring of material micro-nanostructures.

In addition, prominent thin film focus areas and publication topics were identified for articles containing both India and Peoples Republic of China addresses including:

1. Thermally grown ultra-thin silicon dioxide (SiO2) films and characterization of stress-induced leakage currents (SILC) using stressing and sensing measurements. Experimental results provide physical insight into the conduction mechanism of SILC through ultra-thin SiO2 films stressed in the direct tunneling (DT) regime.
2. Development of carbon nanotubes (CNTs) and carbon nanofibers (CNFs) using thermal CVD processes. These materials were used as the electrode platinum support for fuel cell evaluations.
3. Copolymers thin films consisting of oligothiophenes bridged by Si atoms, and the investigation of carrier mobility over a range of doping levels.
4. Development of metal-oxide-semiconductor (MOS) structures with hafnium oxide as the gate dielectric film, and the investigation of current-voltage (I-V) characteristics.

Lastly, prominent thin film focus areas and publication topics were identified for articles containing both India and USA addresses including:

1. Development of Zn1-xMnxO thin films grown on Al2O3 and MgO substrates, and investigation of ferromagnetic behavior, and spin polarization of charge carriers. These single-phase films are being characterized for magnetic semiconductor applications.
2. Development of Cr-doped In2O3 thin films with tunable ferromagnetic behavior over a wide range of doping, or by electrical gating, is being investigated towards realizing spin electronics in magnetic semiconductors and developing spin-based multifunctional devices.
3. Development of amorphous superconducting films driven by a perpendicular magnetic field, and investigation of low-temperature behavior.

The final bibliometric trends provided in the extended collaboration analysis are associated with the use of separate and combined Thin Film topic and INDIA address queries as illustrated in Figures 74a and 74b, for each database. Figure 74a illustrates the comparative total publication trend over the period (1980-2006) for the Thin Film (ONLY), INDIA (ONLY), and Thin Film AND INDIA queries, including associated ratios of total articles.

Figure 74a illustrates several important factors worth noting:

- *The actual total of articles published in the SCI/SSCI database over the period (1980-2006) for the Thin Film (ONLY) query was unavailable as the number exceeded 100,000. Based on the relative results for the India (ONLY) and Thin Film AND India queries for all databases, the number of records for the Thin Film (ONLY) was estimated to be at least 1,500,000.*

- *The total articles retrieved using the Thin Film AND India query from each databases essentially remained constant over the entire period. The total articles retrieved using the Thin Film AND India query from all databases over the entire period equaled 52,116 articles.*
- *The ratio of total articles retrieved using the Thin Film AND India query to total articles retrieved using the Thin Film (ONLY) query suggests that India has accounted for approximately two percent (2%) of the total articles published on thin film research in all three databases over the last 26 years (1980-2006).*
- *The ratio of total articles retrieved using the Thin Film AND India query to total articles retrieved using the India (ONLY) query suggests that thin film research publications have accounted for approximately 5-10 % of the total output production. The ratio obtained for the SCI/SSCI database is low (≈5%) in comparison to the EC and INSPEC databases (> 10%), possibly reflecting the general nature of subject coverage of the EC and INSPEC databases that are more focused on Applied Physical Sciences, Materials Engineering, Electrical Engineering, and Electronics.*

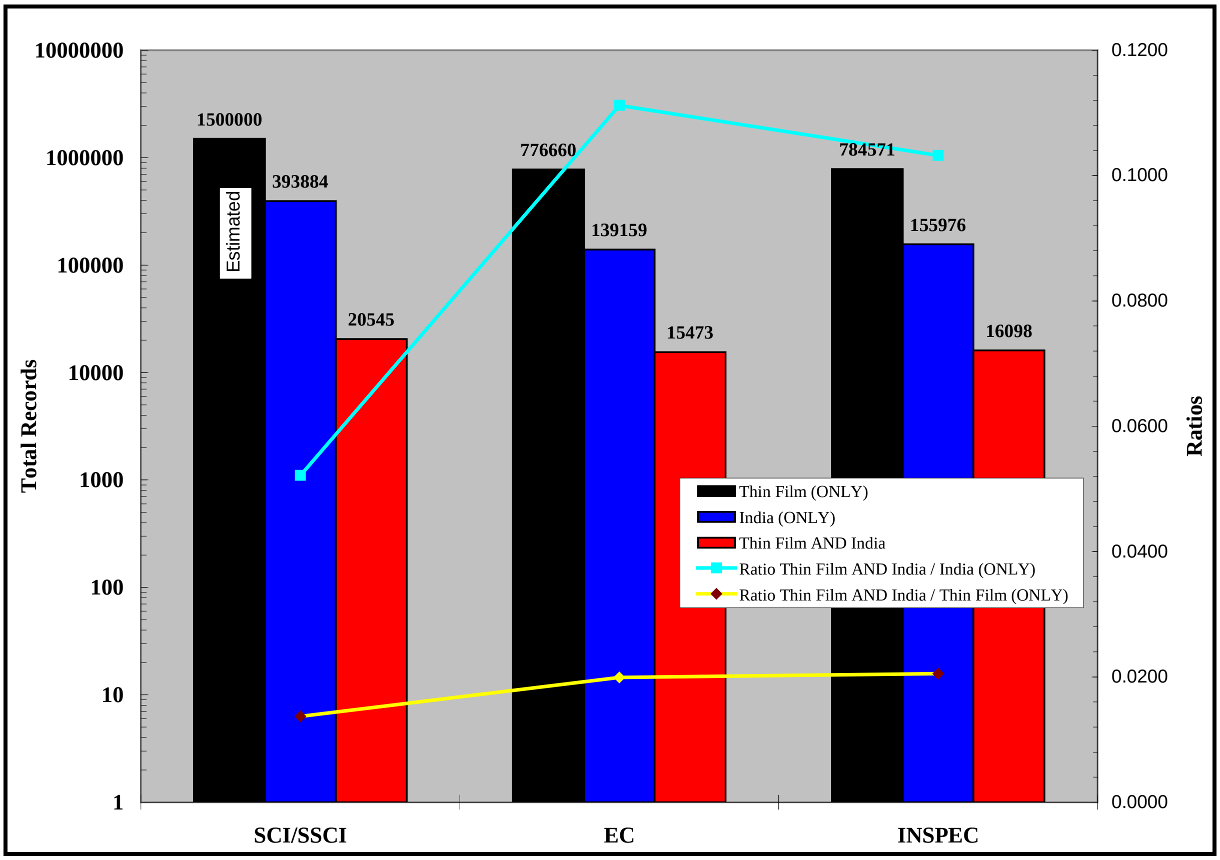

Figure 74a. Comparative Publication Trends (1980-2006)
Separated and Combined Thin Film AND INDIA Address Queries

To provide a final perspective on the countries that dominate globally in thin research output (total publications) over the period (1980-2006), Figure 74b illustrates the relative distribution of total articles retrieved using the Thin Film (ONLY) query for the combined Top 10 countries ranked in each database.

Figure 74b illustrates several important factors worth noting:

- *The total number of combined countries ranked in the Top 10 in each database =12.*
- *The total publication in the SCI/SSCI database (87, 039 articles) is low in comparison to the EC (480,445 articles) and INSPEC (550,010 articles) databases, reflecting the more relevant nature of thin film subject coverage in the EC and INSPEC databases. The total publications from all databases equaled 1,117,496 articles.*
- *The USA as the leader in total publications in all databases (ranked 1st @ 389,684 articles) over the entire period.*
- *The total publications for the Peoples Republic of China (ranked 2nd @ 115,893 articles), is approximately 30% of the total for the USA.*
- *The total publications for India (ranked 9th @ 33,167 articles), is approximately 9% of the total for the USA. Thus, from a global perspective, India is prominent, in terms of both indigenous and collaborative thin film research output, and ranked in the Top 10 nations. Analysis provided above indicated that the predominant countries collaborating with India on thin film research over this period include in order; USA, Germany, France, Japan South Korea, Italy, Taiwan, Peoples R China (2nd in publications), and the United Kingdom.*

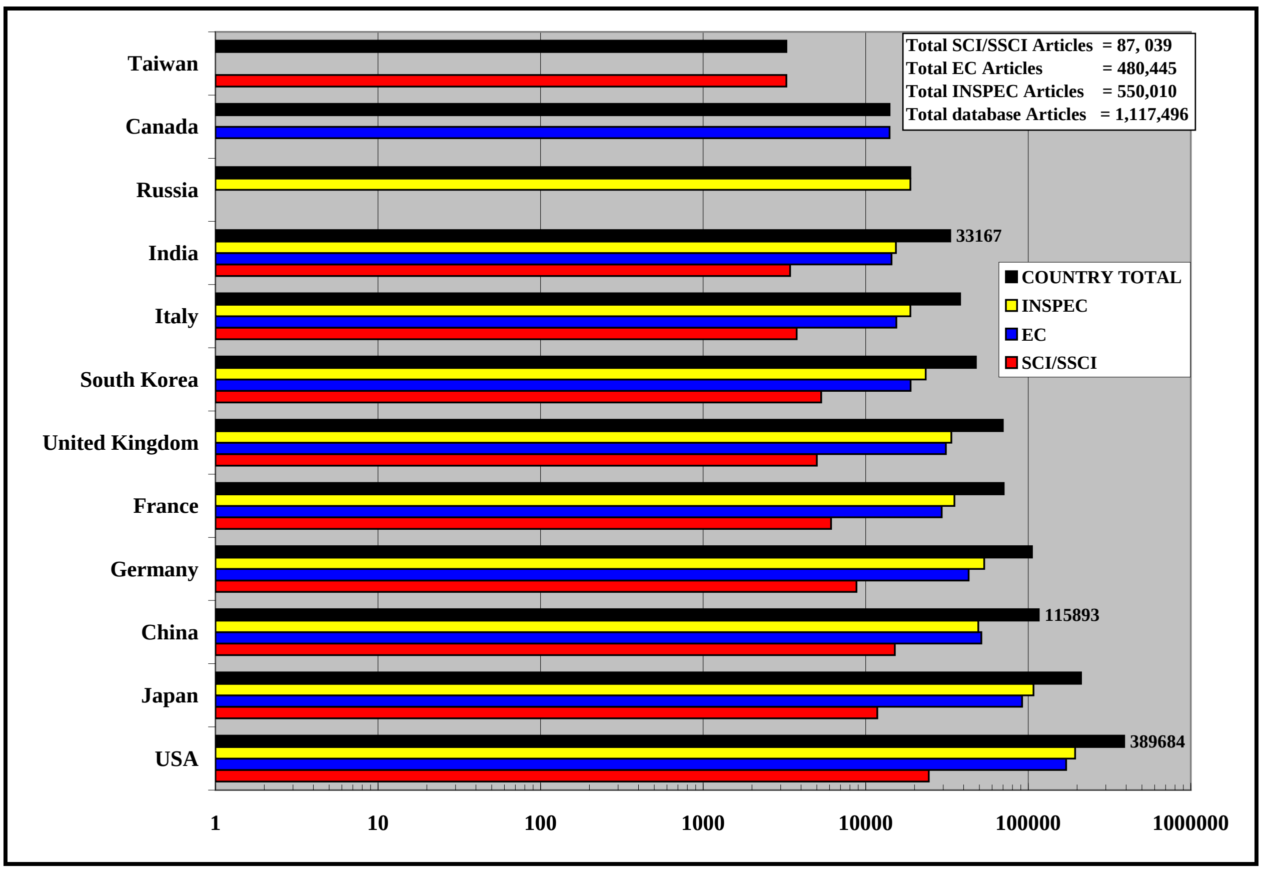

Figure 74b. Comparative Country Thin Film Publication Trends (1980-2006)
Thin Film (ONLY) Query

Since the extended collaboration analyses provided some interesting results on Indian thin film research, an Internet Google survey was conducted to retrieve current information that was not available or reflected in the SCI/SSCI, EC and INSPEC database literature surveys, such as information related to industry involvement. The Internet survey indicates India is currently preparing for a giant leap in the field of photovoltaic's by constructing the world's largest thin-film manufacturing plant (Ref: 8). Applied Materials Silicon Valley has been selected by Moser Baer India Limited to develop and install in New Delhi, the world's first Generation 8.5 Thin Film Solar Module Production Line using ultra-large substrates. These glass panels are four times bigger than today's largest solar panel substrates, and are expected to drive down panel production costs and help reduce the overall cost of solar electricity. This represents a significant collaboration between companies in the U.S and India to establish the first truly modern solar facility in India using semiconductor manufacturing processes. (Ref: 9).

4.2.5 Conclusions: Extended India Research Collaboration Analyses – Thin Films

The extended thin film collaboration analyses provided useful information in regards to addressing the objective questions listed above. The results indicate:

- The extent (scope) of India thin film research in terms of overall output production in a given period (1980-2006) is determined by total publication trends. These trends further indicate a steady publication growth rate during the entire period that has rapidly exceeded 10.4 % for the recent period (2005-2006).

- The extent of India thin film research collaboration with both the USA and China in terms of overall output production in a given period (1990-2006), is determined by total publication trends. The total article and citation trends show steady growth rates during the entire period. The USA has a significantly greater output production (published articles) compared to India.
- Collaborative thin film research with USA and China authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to indigenous research being published by only India authors.
- The specific Journals or Conference Proceedings comprising indigenous India thin film research articles is a broad collection of journals with varying citations and impact factors. The ratio of articles published in the Top 10 Journals to total articles ranges between 19-26 percent and the average Top 10 Journal impact factors ranges between 1.4 and 2.3, for all three databases during the period (2005-2006). The more prominent Journals listed by total article contribution included:

    - JOURNAL OF APPLIED PHYSICS
    - JOURNAL OF MATERIALS SCIENCE
    - JOURNAL OF APPLIED POLYMER SCIENCE
    - JOURNAL OF PHYSICAL CHEMISTRY B
    - THIN SOLID FILMS
    - APPLIED SURFACE SCIENCE
    - SOLAR ENERGY MATERIALS AND SOLAR CELLS
    - SURFACE COATINGS TECHNOLOGY

- Primary collaborating countries other than the USA or China include Germany, Japan, South Korea, France, Taiwan, England, Switzerland and Italy.

- The utility of thin film collaborative research as related to article citations and associated Journal impact factors was determined. The collaborative research is published in higher cited journals, with greater average cites per article and impact factors compared to research being published with only India authors. However, based on use of the Thin Film AND India address query, the ratio of total citations for the Top 1% and Top 5% of articles retrieved to total citations shows a dramatic growth rate for the period (2005-2006). The citation rate for the Top 1% and Top 5% of these articles is extremely high in comparison to the entire preceding period (1980-2005), suggesting that the overall growth rate and utility of thin film research within India is increasing and is being recognized and cited by international researchers.

- Thin film collaborative research is being performed by a multitude of Indian authors and respective affiliations. The Top 25 author affiliations involved in thin film research account for approximately 72% of the total articles retrieved from the SCI/SSCI database, and approximately 17% from the EC and INSPEC databases. The collaborative linkages/groups are illustrated in the author affiliation auto-correlation maps for each database.

- The overall taxonomy of thin film collaborative research in terms of generalized (broad) subject categories includes Materials Science, Physics, Physical Chemistry, Coatings and Films and Electrochemistry as the predominant generalized subject categories. These broad categories account for 90-100% of the total articles retrieved from each database for the period (2005-2006). Overall taxonomies using the India address (ONLY) query for the same period were provided by the CLUTO clustering algorithms for each database. In general, the taxonomies produced by the CLUTO algorithm paralleled the subject coverage areas for each database.

- The present data mining tools and resources (workstation and database levels) used within the present study are adequate to produce useful information from a realm of data. Several of the bibliometric trends over the period (1980-2006) exhibited remarkable symmetry that may not have been identified without the functions of the SCI/SSCI Analyst Tools that proved useful in excluding records from the collaboration analyses. Refinements to the overall processing of raw records should be considered, as certain improvements are required in handling large record datasets and huge memory files, for computers other than the dedicated data mining workstations at the Office of Naval Research (ONR). Currently, the processing time for records and files on computer laptops is extremely lengthy, and software upgrades to the TechOasis Package should be considered for supporting future data mining studies at remote locations other than ONR.

Finally, for reference purposes, the following paragraphs summarize the formulation of the expanded thin film query. The specific topic search terms used in the query were derived by analyzing the Level 4 clusters (for each database) that categorized thin films as research focus areas. The taxonomies shown above in Tables 22, 24 and 25, comprised 256 total clusters for the

SCI/SSCI and EC databases, and 128 total clusters for the INSPEC database, respectively. These taxonomies each contained sixteen (16) Level 4 clusters that were further segmented into their respective Leaf clusters to retrieve more detailed information on India thin film research publications. The information produced by the CLUTO clustering algorithm includes double and triple word terminology that was analyzed to derive specific thin film query terms. The following paragraphs provide listings of the leaf cluster terminology produced for each relevant Level 4 cluster in all three databases.

SCI/SSCI Thin Film Cluster {499}

SCI/SSCI Cluster {499} 4,806 records; 2 Leaf Clusters {89, 130})

Cluster 499 Leaf Cluster 89 (512 records):
Double Word Terms
thin.films 388, band.gap 167, ray.diffraction 151, glass.substrates 134, films.deposited 120, room.temperature 106, thin.film 105, optical.band 79, optical.absorption 73, optical.properties 68, scanning.electron 66, electron.microscopy 62, substrate.temperature 58, diffraction.xrd 52, tin.oxide 49, electrical.resistivity 49, films.ray 46, electrical.properties 45, sol.gel 45, spray.pyrolysis 41
Triple Word Terms
thin.films.deposited 77, optical.band.gap 74, ray.diffraction.xrd 51, scanning.electron.microscopy 42, films.ray.diffraction 40, zno.thin.films 30, pulsed.laser.deposition 30, coated.glass.substrates 27, transmission.electron.microscopy 26, films.deposited.glass 26, deposited.glass.substrates 26, electron.microscopy.sem 25, band.gap.energy 25, oxide.thin.films 24, energy.dispersive.ray 24, thin.films.grown 24, chemical.bath.deposition 24, atomic.force.microscopy 23, optical.electrical.properties 22, doped.tin.oxide 22

Cluster 499 Leaf Cluster 130 (521 records):
Double Word Terms
thin.films 96, ray.diffraction 90, films.deposited 86, atomic.force 75, force.microscopy 62, electron.microscopy 62, room.temperature 59, scanning.electron 58, properties.films 37, grain.size 36, film.thickness 35, diffraction.xrd 33, sol.gel 33, films.films 31, microscopy.afm 31, fourier.transform 30, surface.morphology 29, transmission.electron 28, thin.film 27, ray.photoelectron 26
Triple Word Terms
atomic.force.microscopy 62, scanning.electron.microscopy 36, ray.diffraction.xrd 32, force.microscopy.afm 31, fourier.transform.infrared 26, ray.photoelectron.spectroscopy 23, transmission.electron.microscopy 21, electron.microscopy.sem 17, films.ray.diffraction 16, pulsed.laser.deposition 14, langmuir.blodgett.films 14, transform.infrared.spectroscopy 14, chemical.vapor.deposition 12, energy.dispersive.ray 12, tungsten.oxide.wo3 12, air.water.interface 11, average.grain.size 11, scanning.electron.microscope 10, thin.films.deposited 10, transform.infrared.ftir 10

EC Thin Film Clusters {310, 361}

EC (Cluster {310} 385 records; 2 Leaf Clusters {196, 218})

Cluster 310 Leaf Cluster 196 (276 records):
Double Word Terms:
thin.films 56, atomic.force 36, electron.microscopy 36, ray.diffraction 34, force.microscopy 29, scanning.electron 29, room.temperature 27, film.thickness 27, sol.gel 22, films.deposited 21, langmuir.blodgett 21, films.films 17, copy.indian 16, oxide.films 16, thin.film 16, properties.films 15, microscopy.afm 15, grain.size 14, tungsten.oxide 14, transmission.electron 14
Triple Word Terms:
atomic.force.microscopy 29, scanning.electron.microscopy 23, force.microscopy.afm 15, langmuir.blodgett.films 14, fourier.transform.infrared 13, air.water.interface 10, transmission.electron.microscopy 9, ray.photoelectron.spectroscopy 9, tungsten.oxide.films 9, sol.gel.derived 8, ray.diffraction.xrd 8, ion.storage.capacity 7, electron.microscopy.sem 7, films.ray.diffraction 7, atomic.force.microscope 7, glass.transition.temperature 6, metal.insulator.transition 6, density.polyethylene.ldpe 6, differential.scanning.calorimetry 6, energy.dispersive.ray 6

Cluster 310 Leaf Cluster 218 (109 records):
Double Word Terms:
thin.films 19, room.temperature 18, scanning.electron 18, electron.microscopy 14, cyclic.voltammetry 12, electrical.conductivity 11, atomic.force 10, fourier.transform 10, polymer.film 10, alcohol.pva 9, polymer.films 9, conducting.polymer 9, ray.diffraction 9, polyvinyl.alcohol 9, transform.infrared 8, band.gap 8, thin.film 8, polyaniline.pani 7, surface.morphology 7, copy.indian 7
Triple Word Terms
scanning.electron.microscopy 10, fourier.transform.infrared 8, atomic.force.microscopy 7, transform.infrared.spectroscopy 6, indium.tin.oxide 6, polyvinyl.alcohol.pva 6, differential.scanning.calorimetry 6, tin.oxide.ito 5, poly.methyl.methacrylate 5, surface.plasmon.resonance 5, films.cyclic.voltammetry 5, glassy.carbon.electrode 5, electron.microscopy.sem 5, transmission.electron.microscopy 5, four.wave.mixing 4, alcohol.pva.films 4, dye.doped.gelatin 4, degenerate.four.wave 4, charge.transfer.complexes 4, methyl.methacrylate.pmma 4

EC (Cluster {361} 533 records; 3 Leaf Clusters {114, 102, 117})

Cluster 361 Leaf Cluster 114 (245 records):
Double Word Terms
films.deposited 138, thin.films 134, ray.diffraction 96, glass.substrates 61, substrate.temperature 47, band.gap 46, scanning.electron 42, deposited.films 40, atomic.force 39, grain.size 38, diffraction.xrd 33, films.ray 31, room.temperature 31, optical.properties 31, electron.microscopy 31, properties.films 29, magnetron.sputtering 29, force.microscopy 28, films.grown 28, optical.absorption 27

Triple Word Terms
thin.films.deposited 47, ray.diffraction.xrd 33, atomic.force.microscopy 28, films.ray.diffraction 27, scanning.electron.microscopy 22, coated.glass.substrates 17, deposited.glass.substrates 17, ray.photoelectron.spectroscopy 16, pulsed.laser.deposition 16, force.microscopy.afm 15, optical.band.gap 15, scanning.electron.microscope 15, zno.thin.films 14, thin.films.grown 13, chemical.vapor.deposition 13, films.deposited.glass 13, indium.tin.oxide 12, fourier.transform.infrared 12, transmission.electron.microscopy 12, electron.microscope.sem 11

Cluster 361 Leaf Cluster 102 (155 records):
Double Word Terms
thin.films 131, band.gap 99, glass.substrates 55, ray.diffraction 54, optical.band 54, films.deposited 46, room.temperature 40, optical.absorption 35, optical.properties 33, spray.pyrolysis 33, electrical.resistivity 26, tin.oxide 25, scanning.electron 24, diffraction.xrd 23, electron.microscopy 22, electrical.conductivity 22, properties.films 22, oxide.thin 21, fluorine.doped 20, electrical.properties 20
Triple Word Terms
optical.band.gap 50, thin.films.deposited 32, ray.diffraction.xrd 23, oxide.thin.films 21, doped.tin.oxide 19, films.ray.diffraction 18, scanning.electron.microscopy 17, fluorine.doped.tin 16, optical.electrical.properties 15, band.gap.energy 14, deposited.glass.substrates 13, direct.band.gap 12, films.deposited.glass 12, optical.properties.films 11, ray.photoelectron.spectroscopy 11, tin.oxide.fto 11, chemical.bath.deposition 11, conducting.glass.substrates 10, electrical.optical.properties 10, cdse.thin.films 10

Cluster 361 Leaf Cluster 117 (133 records):
Double Word Terms
thin.films 118, thin.film 47, ray.diffraction 34, glass.substrates 23, atomic.force 22, electron.microscopy 21, force.microscopy 19, films.grown 18, room.temperature 15, optical.properties 14, sol.gel 13, microscopy.afm 13, films.deposited 13, pulsed.laser 13, transmission.electron 13, laser.deposition 12, scanning.electron 12, band.gap 12, surface.morphology 12, grain.size 11
Triple Word Terms
atomic.force.microscopy 19, thin.films.grown 15, force.microscopy.afm 13, transmission.electron.microscopy 12, pulsed.laser.deposition 12, thin.films.deposited 11, scanning.electron.microscopy 10, ray.diffraction.xrd 9, oxide.thin.films 8, electron.microscopy.sem 6, indium.tin.oxide 6, tio.thin.films 6, properties.thin.films 6, electron.microscopy.tem 5, rutherford.backscattering.spectrometry 5, films.deposited.glass 5, thin.films.fabricated 5, deposited.thin.films 5, films.ray.diffraction 5, properties.thin.film 5

INSPEC Thin Film Cluster {199}

INSPEC Cluster {199} 1,091 records; 4 Leaf Clusters {87, 29, 104, 94}

Cluster 199 Leaf Cluster 87 (401 records):
Double Word Terms
thin.films 144, atomic.force 57, thin.film 53, force.microscopy 45, ray.diffraction 37, room.temperature 37, sol.gel 34, film.thickness 33, scanning.electron 29, electron.microscopy 28, microscopy.afm 27, dielectric.constant 21, properties.films 20, films.deposited 20, grain.size 18, films.grown 17, refractive.index 16, electrical.conductivity 16, cyclic.voltammetry 15, glass.substrates 15
Triple Word Terms
atomic.force.microscopy 45, force.microscopy.afm 27, scanning.electron.microscopy 15, fourier.transform.infrared 12, differential.scanning.calorimetry 11, sol.gel.derived 10, atomic.force.microscope 9, transmission.electron.microscopy 9, langmuir.blodgett.films 9, scanning.calorimetry.dsc 8, ray.photoelectron.spectroscopy 8, ray.diffraction.xrd 8, pulsed.laser.deposition 8, swift.heavy.ion 8, coated.glass.substrates 7, films.ray.diffraction 7, polyvinyl.alcohol.pva 7, tio.thin.films 7, films.atomic.force 7, sol.gel.spin 7

Cluster 199 Leaf Cluster 29 (385 records):
Double Word Terms
thin.films 272, ray.diffraction 155, films.deposited 153, band.gap 139, glass.substrates 117, optical.band 73, scanning.electron 71, room.temperature 68, electron.microscopy 65, substrate.temperature 63, optical.absorption 60, optical.properties 58, diffraction.xrd 55, tin.oxide 50, grain.size 49, thin.film 49, films.grown 47, deposited.films 46, atomic.force 44, properties.films 43
Triple Word Terms
thin.films.deposited 76, optical.band.gap 68, ray.diffraction.xrd 55, scanning.electron.microscopy 44, films.ray.diffraction 37, atomic.force.microscopy 30, oxide.thin.films 28, deposited.glass.substrates 28, transmission.electron.microscopy 27, films.deposited.glass 26, band.gap.energy 25, electron.microscopy.sem 25, coated.glass.substrates 24, doped.tin.oxide 24, thin.films.grown 23, energy.dispersive.ray 21, chemical.bath.deposition 21, fluorine.doped.tin 21, zno.thin.films 20, optical.electrical.properties 20

Cluster 199 Leaf Cluster 104 (161 records):
Double Word Terms
ray.diffraction 39, electron.microscopy 23, atomic.force 21, ray.photoelectron 20, photoelectron.spectroscopy 20, ray.reflectivity 20, room.temperature 19, force.microscopy 19, surface.morphology 15, films.deposited 14, microscopy.afm 13, thin.films 13, magnetron.sputtering 13, scanning.electron 13, spectroscopy.xps 12, transmission.electron 11, thin.film 11, grain.size 10, 400.deg 10, diffraction.xrd 10
Triple Word Terms
ray.photoelectron.spectroscopy 20, atomic.force.microscopy 19, force.microscopy.afm 13, scanning.electron.microscopy 12, photoelectron.spectroscopy.xps 12, ray.diffraction.xrd 10, grazing.incidence.ray 8, transmission.electron.microscopy 8, incidence.ray.reflectivity 7,

ray.diffraction.ray 6, electron.microscopy.sem 6, angle.ray.diffraction 5, electron.beam.evaporation 5, diffraction.ray.photoelectron 5, ray.diffraction.measurements 5, ray.diffraction.pattern 5, pulsed.laser.deposition 5, ray.reflectivity.data 5, fourier.transform.infrared 5, high.resolution.transmission 4

Cluster 199 Leaf Cluster 94 (144 records):
Double Word Terms
current.density 28, current.voltage 27, thin.films 24, room.temperature 20, thin.film 18, capacitance.voltage 18, electrical.properties 18, barrier.height 16, chemical.vapor 15, leakage.current 14, vapor.deposition 13, doping.concentration 11, porous.silicon 11, films.deposited 11, hot.wire 10, field.emission 10, state.density 10, electron.microscopy 10, solar.cells 9, solar.cell 9
Triple Word Terms
chemical.vapor.deposition 13, space.charge.limited 9, hot.wire.chemical 8, wire.chemical.vapor 8, hydrogenated.amorphous.silicon 7, hydrogen.silsesquioxane.hsq 7, open.circuit.voltage 7, amorphous.silicon.carbon 7, metal.oxide.semiconductor 7, interface.state.density 7, barrier.height.phi 6, vapor.deposition.hwcvd 6, current.voltage.capacitance 6, voltage.capacitance.voltage 6, current.density.voltage 6, scanning.electron.microscopy 5, ray.photoelectron.spectroscopy 5, chemical.vapour.deposition 5, silicon.carbon.sic 5, schottky.barrier.height 5

4.3 Extended India Research Collaboration Analysis – Crops/Soil Research

The document clustering results obtained for the SCI/SSCI, EC, and INSPEC databases (Level 4 Clusters) for the period (2005-2006) identified themes or single technology focus areas of India research. The results (total records) for SCI/SSCI Cluster {494}, EC Cluster {502} and INSPEC Cluster {233} indicate that crops/soil (agronomy) research is one viable single focus area that warrants extended research collaboration analyses. The collaboration analyses discussed below parallel the analyses presented above in section 4.2 for solid thin research. The total combined records assigned to the crops/soil cluster groupings for each database were as follows:

1. SCI/SSCI Cluster {494}: 3,835 records (8.2 % of 46,819 total records)
2. EC Cluster {502}: 3,997 records (16.9% of 23,584 records)
3. INSPEC Cluster {233}: 1,789 records (9.5 % of 23,584 records)

Therefore, a generalized single technology query was developed to retrieve the maximum number of records from each database in order to conduct extended India research collaboration analyses focused on crops/soil (agronomy) research. Specifically, the analyses are focused on India research collaboration with the United States (USA) and Peoples Republic of China based on co-authorship. The specific questions the collaboration analyses attempts to answer are identical to those addressed for solid thin film research listed above in Section 4.2.

The analyses comprise gross bibliometrics for all primary collaborating countries, prominent journals, author affiliations, and thin film subject categories. The analyses also comprise detailed publication and citation trend analyses for the period (2005-2006) and for the extended period (1980-2005) by intervals. The following three sections provide the results of the collaboration analyses for the SCI/SSCI, EC and INSPEC databases, respectively. The respective analyses are based on a generalized Boolean search query with combined Topic (crops) "AND" Author Country Address search term(s) of the form:

- TS/TO* = (Topic Search Term(s)) AND CU/CO* = (Author Country Address Search Term(s)) where:

- TS/TO* = ((crop or crops or rice or wheat or (irrigation and soil) or sorghum or groundnut or maize or soybean or intercropping or sowing or grain yield or planting or tillage or millet or fruit or farmyard or agricultur* or potato) not (diet or diets or sensory or meals or dessert or fat* or frying or fried or (dried and fruit) or liver or diabetes or metabolism or arthritis or enteritis or fermentation or cancer or (heart and disease)))

- CU/CO* = One of five Author Country Address search terms as follows:

  1. INDIA
  2. USA
  3. CHINA
  4. INDIA AND USA NOT CHINA (SCI/SSCI Only)
  5. INDIA AND CHINA NOT USA (SCI/SSCI Only)

The Topic search terms were derived in the preceding study from detailed analysis of the document clustering results, with specific focus on themes, keywords, technical phrases, article titles (leaf clusters) and journal information produced by the CLUTO clustering algorithm. Therefore, the collaboration analyses discussed below are extensions of the preceding analysis that focused only on the SCI/SSCI database. It should be noted that the Boolean Author Country Address search terms (4 and 5) were used only in the SCI/SSCI analysis since the EC and INSPEC database Author Address fields are single-valued and do not allow Boolean search operators (e.g., AND, NOT, etc.).

* TS/CU combination is for the SCI/SSCI database.
TO/CO combination is for both the EC and INSPEC databases.

4.3.1 SCI/SSCI Crops/Soil Research Collaboration Analyses

The SCI/SSCI collaboration analyses were conducted using the expanded crops and INDIA (Address 1) query for the period (2005-2006). The query retrieved 2300 total records and gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (INDIA):

- USA (107), Germany (38), England (35), South Korea (30), Australia (29), Peoples R China (25), Philippines (25), Japan (23), France (19), Netherlands (16)

Top 10 Sources (journals):

- 705 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 1.052
- Five of the Top 10 Journals are Indian Journals

Top 10 Author Affiliations:

- 754 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- All of the Top 10 affiliations are Indian affiliations (India address)

Top 10 Subject Categories:

- 2,180 total articles are classified in the Top 10 subject categories
- Agronomy, Plant Sciences, Agriculture, Multidisciplinary Food Science & Technology, Environmental Sciences, Biotechnology & Applied Microbiology, Biochemistry & Molecular Biology, Multidisciplinary Sciences, Horticulture, Agriculture, and Soil Science are the predominant generalized subject categories.

A comparative analysis using the expanded crops and USA (Address 2) query retrieved 11,613 articles, compared to INDIA with 2,300 articles. The gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (USA):

- Peoples R China (409), Canada (337), Germany (230), England (193) , Mexico (174), Japan (167), Brazil (162), Australia (161), France (139), South Korea (133)
- INDIA (260) was listed as Country number 14

Top 10 Sources (journals):

- 2,037 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 1.458
- 9 of the Top 10 Journals are USA Journals

Top 10 Author Affiliations:

- 5132 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- All of the Top 10 affiliations are USA affiliations (USA address)

Top 10 Subject Categories:

- 10,082 total articles are classified in the Top 10 subject categories
- Plant Sciences, Agronomy, Environmental Sciences, Horticulture, Ecology, Entomology, Food Science & Technology, Agriculture, Soil Science, Biotechnology & Applied Microbiology, And Biochemistry & Molecular Biology are the predominant generalized subject categories

A similar comparative analysis was conducted using the expanded crops and CHINA (Address 3) query that retrieved 3,287 articles, compared to USA with 11,613 articles, and INDIA with 2,300 articles. The gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (CHINA):

- USA (409), Japan (176), Australia (105), Germany (85), Canada (83), England (64), Netherlands (45), Philippines (43), South Korea (29), Mexico (26)
- INDIA (25) was listed as Country number 11

Top 10 Sources (journals):

- 597 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 1.263
- 4 of the Top 10 Journals are Chinese Journals

Top 10 Author Affiliations:

- 2,353 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- All of the Top 10 affiliations are Chinese affiliations (Peoples R China address)

Top 10 Subject Categories:

- 3,435 total articles are classified in the Top 10 subject categories
- Plant Sciences, Agronomy, Biochemistry & Molecular Biology, Environmental Sciences, Agriculture, Soil Science, Food Science & Technology, Biotechnology & Applied Microbiology, Horticulture, Genetics & Heredity, and Applied Chemistry are the predominant generalized subject categories

Note that the SCI/SSCI address search field is a multi-valued field that lists multiple countries for each retrieved article. The use of the expanded crops with INDIA, USA or CHINA query search terms retrieves all articles with the specific address and may include other affiliated Country addresses. Therefore, to further separate the bibliometrics regarding USA and CHINA collaboration with INDIA, similar comparative analyses were conducted using the expanded crops query with the Boolean author country address search terms (Addresses 4 and 5 above).

The expanded crops with INDIA AND USA NOT CHINA (Address 4) query retrieved 102 articles. The gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (INDIA AND USA NOT CHINA):

- Philippines (5), France (4), Germany (4), England (3), Australia (2), Canada (2), Greece (2), Israel (2), Japan (2), Mexico (2)

Top 10 Sources (journals):

- 25 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 1.393
- One of the Top 10 Journals is an Indian Journal

Top 10 Author Affiliations:

- 72 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields
- 4 of the Top 10 affiliations are Indian affiliations (India address)
- 31 (43%) total articles are attributed to the Top 4 Indian affiliations

Top 10 Subject Categories:

- 92 total articles are classified in the Top 10 subject categories
- Plant Sciences, Agronomy, Biochemistry & Molecular Biology, Biotechnology & Applied Microbiology, Environmental Sciences, Water Resources, Agriculture, Soil Science, Genetics & Heredity, Multidisciplinary Sciences, And Ecology are the predominant generalized subject categories

The expanded crops with INDIA AND CHINA NOT USA (Address 5) query retrieved 20 articles. The gross collaboration bibliometrics indicate the following:

Top 10 Countries Listed with (INDIA AND CHINA NOT USA):

- Australia (2), Germany (2), Bangladesh (1), Brazil (1), England (1), Estonia (1), Indonesia (1), Iran (1), Japan (1), Mexico (1)

Top 10 Sources (journals):

- 12 total articles were published in the Top 10 journals
- The average Top 10 Journal impact factor (IF) = 0.773
- Two of the Top 10 Journals are Indian Journals

Top 10 Author Affiliations:

- 21 total articles are attributed to the Top 10 author affiliations. Note that SCI/SSCI articles contain multiple values for author affiliation fields. Note also that articles may be published in multiple journals
- 5 of the Top 10 affiliations are Indian affiliations (India address)
- 11 (52%) total articles are attributed to the Top 4 Indian affiliations

Top 10 Subject Categories:

- 27 total articles are classified in the Top 10 subject categories
- Plant Sciences, Agronomy, Biochemistry & Molecular Biology, Multidisciplinary Sciences, and Water Resources are the predominant generalized subject categories

In addition to the gross bibliometric results, Table 36 provides detailed publication and citation analysis results for the period (2005-2006) for each of the five expanded crops queries. The highlighted unavailable data is associated with record retrievals greater than 10,000 records, for which, citation reports are not available using SCI/SSCI database Analyst Tools.

TABLE 36. SCI/SSCI (2005-2006) COUNTRY ADDRESS BIBLIOMETRICS COMPARISON (CROPS QUERY)

SCI / SSCI Single Technology (CROPS QUERY) Country Collaboration - Citation Bibliometrics (2005-2006)					
Bibliometrics / Country Address	**INDIA**	**USA**	**CHINA**	**INDIA AND USA NOT CHINA**	**INDIA AND CHINA NOT USA**
Total Articles (2005-2006)	**2,300**	**11,613**	**3,287**	**102**	**20**
Total Articles Published Top 10 Journals	**705**	**2,037**	**597**	**25**	**12**
Total Citations*	**1,740**	**NA>10,000**	**4,381**	**109**	**9**
Total Citations (Top 1% Articles)*	**481**	**11,300**	**858**	**15**	**2**
Median Citation (Top 1% Articles)*	**11**	**21**	**14**	**15**	**2**
Median Citation (Top 5% Articles)*	**5**	**10**	**8**	**6**	**2**
Median Citation (Top 10 Articles)*	**17**	**48**	**34**	**4**	**1**
Average Cites per Article*	**0.76**	**NA>10,000**	**1.33**	**1.07**	**0.45**

Figure 75 illustrates select results from Table 36 including total and median article citations for the Top 1% and 5% of the total number of articles, and for the Top 10 cited articles for the period (2005-2006).

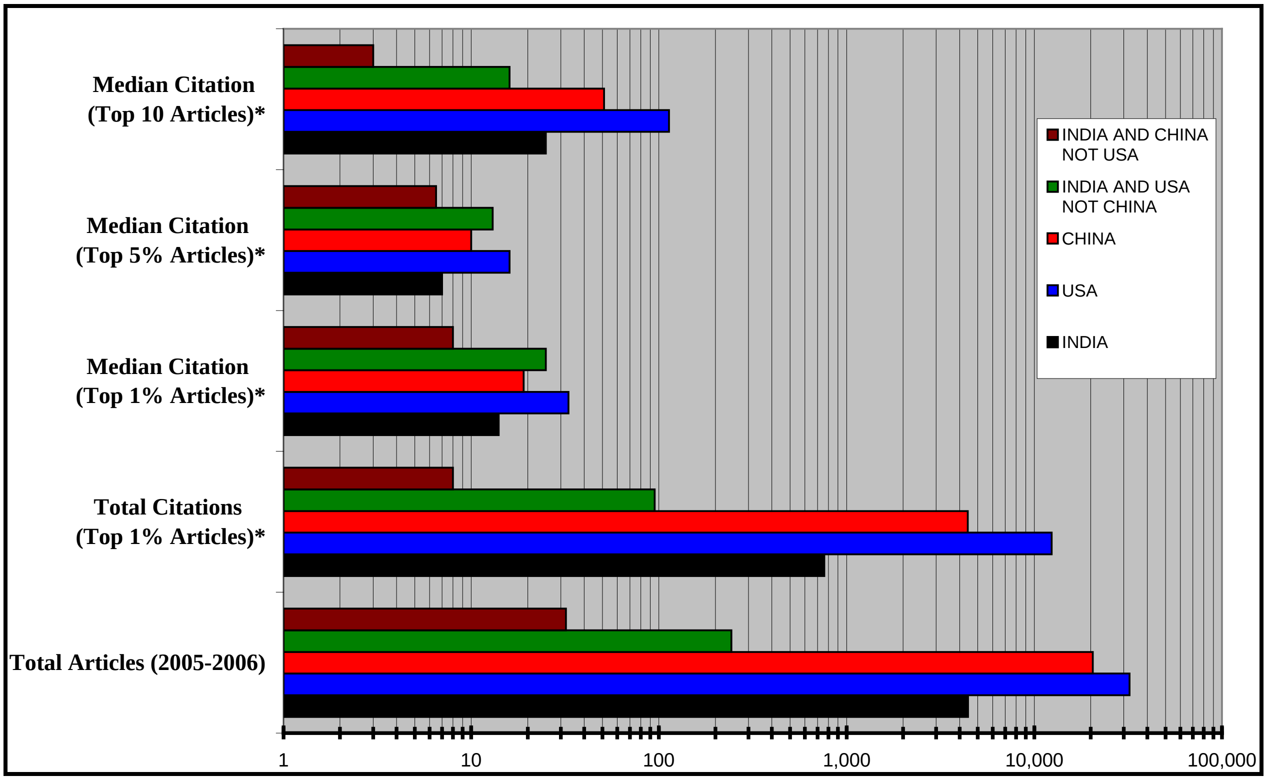

Figure 75. SCI/SSCI (2005-2006) Country Address Bibliometrics Comparison (Crops Query)

Figure 75 illustrates several important factors worth noting:

- *USA has a significantly greater output production (published articles) compared to India than China.*

- *USA and China have comparable output production (published articles), however China has a significantly decrease in total and median citations.*

- *The median citations of the Top 1% and Top 5% of the total articles is significantly greater for articles with INDIA AND USA author addresses compared to articles with INDIA only; and similarly comparable for the Top 10 articles. This suggests that collaborative research with USA authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to research being published with only India authors. Note that Table 36 indicates the average cites per article with INDIA AND USA author addresses (1.07), compared to INDIA author addresses (0.76).*

- *The Top 10 Journals containing articles with INDIA addresses account for 30% of the total articles. The Top 10 Journals containing articles with INDIA AND USA NOT CHINA addresses account for 25% of the total articles. The Top 10 Journals containing articles with INDIA AND CHINA NOT USA addresses account for 60% of the total articles. This suggests that both indigenous and collaborative research with USA or CHINA is being published in a narrower group of high quality, highly cited Journals.*

It should be noted that the Boolean operators (inclusive AND, and exclusive NOT) that combine INDIA, USA and CHINA in the address queries analyzed above do not preclude other possible affiliated Country addresses. For example, the (INDIA AND USA NOT CHINA) query retrieves all research articles with both INDIA and USA addresses; however, other affiliated country addresses can also be included. The query ONLY excludes CHINA addresses.

To gain even a further perspective into the individual collaboration between the USA and CHINA with INDIA, detailed article publication and citation analyses was conducted over an extended period (1980-2005, and 2005-2006) by intervals to establish comparative trends. The analysis was conducted by using the expanded crops and INDIA address query for each of the listed intervals (80-85, 85-90, etc.). The SCI/SSCI Analyst Tool was then used to select all articles containing INDIA, INDIA with USA, and INDIA with CHINA, *while excluding all other listed affiliated Country addresses*. As such, the analysis presented in the following paragraphs focuses on INDIA collaboration between the USA and CHINA ONLY.

Table 37 provides a listing of the overall publication trend for the first query (expanded crops query and INDIA) including total articles published in the Top 10 journals, and average Top 10 Journal IF for the entire period (1980-2006) by intervals. Table 37 provides a comparison to EC and INSPEC database publication trends given below in Table 39 and Table 40, respectively

TABLE 37. SCI/SSCI (1980-2006) PUBLICATION AND JOURNAL IMPACT FACTOR TRENDS (CROPS QUERY AND INDIA)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	**2729**	**2794**	**3949**	**4929**	**5980**	**2300**
Top 10 Journal Records	**1237**	**1156**	**1500**	**2058**	**2171**	**705**
Ratio (Top 10 Journal Records / Total Records)	**0.453**	**0.414**	**0.380**	**0.418**	**0.363**	**0.307**
Average Journal IF	**1.057**	**0.556**	**0.625**	**0.833**	**1.072**	**1.052**

Table 38 provides a complete summary of analysis results including SCI/SSCI publication (total records), citation (median and average) and Journal IF bibliometrics for all articles retrieved using INDIA, INDIA with USA, and INDIA with CHINA addresses. Note for comparison that the first row listed in Table 38 contains the total records retrieved from the SCI/SSCI database using INDIA (ONLY) as the country address search term with NO Topic (e.g., Crops/Soil) term(s). Figure 76 illustrates select results from Table 38 including total articles published for the expanded crops AND INDIA address query, and the INDIA (ONLY) query (for comparison). Table 38 also lists citations bibliometrics, including median and average cites for the Total Number, Top 1%, and Top 5% of the total number of articles retrieved using the expanded query. Figure 77 illustrates the respective article citation ratios and overall publication trend.

TABLE 38. SCI / SSCI (1980-2006) COUNTRY COLLABORATION
(ARTICLE PUBLICATION AND CITATION TREND COMPARISON)

Bibliometrics / Time Period	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2006
X = Total Articles (India)	64600	67416	73202	92909	100000	52047
Total Articles (India AND Crops Query)	2729	2794	3,949	4,929	5,980	2,300
Total Articles (India AND Crops Query) with USA	35	42	108	170	314	107
Total Articles (India AND Crops Query) with China	0	0	2	13	40	25
Total Citations* (India AND Crops Query)	10081	10454	16,229	20,295	17,031	1,740
Total Citations* (India AND Crops Query) with USA	380	450	1402	1926	2406	321
Total Citations* (India AND Crops Query) with China	0	0	18	311	519	221
Median Citation (Top 10 Articles)* (India AND Crops Query)	70	61	71	77	91	17
Median Citation (Top 10 Articles)* (India AND Crops Query) with USA	19	20	59	43	42	6
Median Citation (Top 10 Articles)* (India AND Crops Query) with China	1	1	9	16	21	2
Average Cites per Article* (India AND Crops Query)	3.69	3.74	4.11	4.12	2.85	0.76
Average Cites per Article* (India AND Crops Query) with USA	10.86	10.71	12.98	11.33	7.66	3.00
Average Cites per Article* (India AND Crops Query) with China	1	1	9.00	23.92	12.98	8.84
Average Top 10 Journal IF (India AND Crops Query)	1.122	0.521	0.538	0.823	1.026	0.914
Average Top 10 Journal IF (India AND Crops Query) with USA	1.347	1.910	1.644	1.379	1.230	1.296
Average Top 10 Journal IF (India AND Crops Query) with China	0.000	0.000	0.719	1.524	1.256	0.863

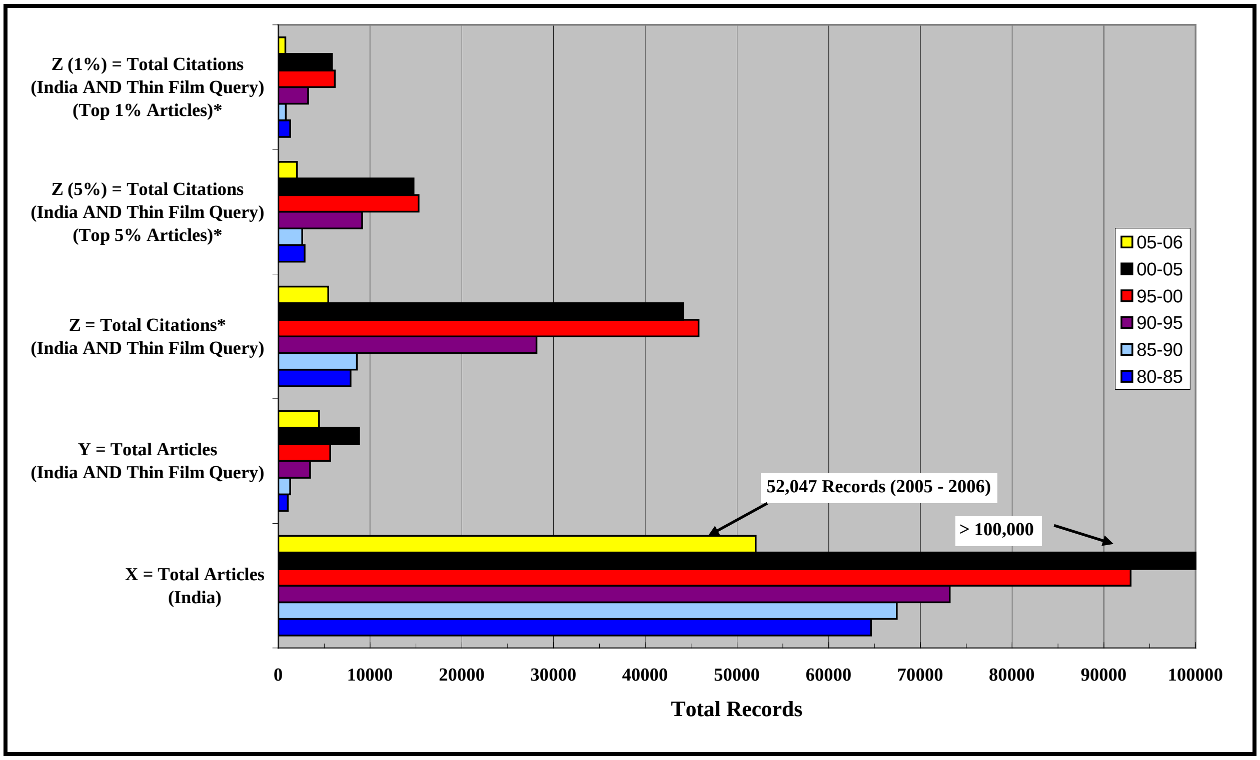

Figure 76. SCI/SSCI (1980-2006) Publication and Citation Trend Comparison
(Crops AND INDIA Query)

Figure 76 illustrates several important factors worth noting:

- *The total articles retrieved using the (Crops and India) query shows a steady publication growth rate during the entire period (1980-2006).*
- *The total citations for articles retrieved using the (Crops and India) query shows a steady growth rate during the period (1980-2000)*
- *The trends for total citations of the Top 1% and Top 5% of the most cited articles are identical to the trend for total citations of ALL articles.*
- *The highlighted total articles for the India address (ONLY) query (52,047) records during the period (2005-2006) forms the basis for the present study and is included for comparison.*

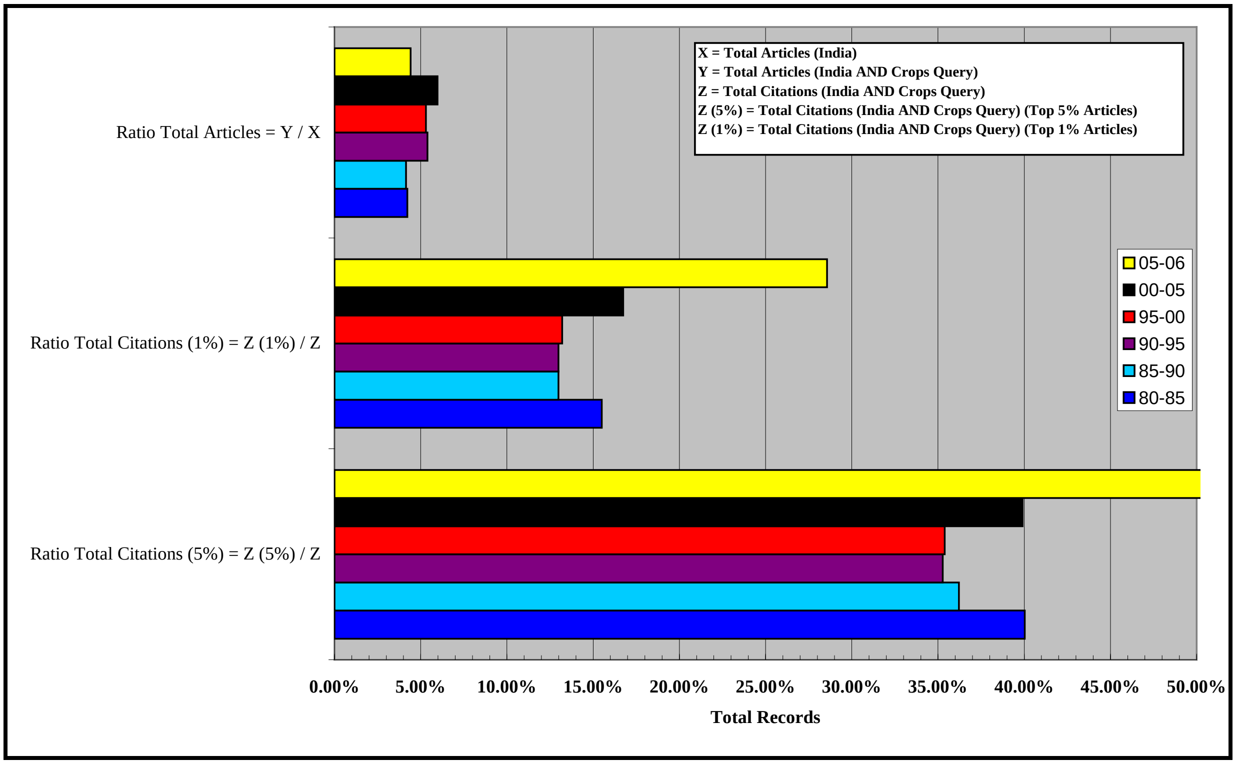

Figure 77. SCI/SSCI (1980-2006) Publication and Citation Ratio Trend
(Crops AND INDIA Query)

Figure 77 illustrates several important factors worth noting:

- *The ratio of total articles retrieved using the Crops and India query to total articles retrieved using the India address (ONLY) query shows a steady output trend for the entire period (1980-2005). Note that the ratio for (2005-2006) already approximates the ratio for (2000-2005), and is anticipated to exhibit steady growth in overall percentage of articles for the future period (2007-2010).*
- *This publication trend is exhibited in the EC and INSPEC analysis results, and supports the finding (clustering results) that crops/soil (agronomy) is a predominant focus area of India research that is being published and prominently cited. This trend also supports the selection to include the topic of crops/soil research within the present collaboration analysis.*
- *The ratio of total citations for the Top 1% and Top 5% of articles retrieved using the Crops and India query to total citations shows a dramatic growth rate for the period (2005-2006). During this period, 2,300 total articles were retrieved with 1,740 total citations through 2007. The citation rate for the Top 1% and Top 5% of these articles is extremely high in comparison to the entire preceding period (1980-2005).*
- *During the period (1980-1985), there were 2,729 articles retrieved using the India and Crops query with 10,081 total current citations through 2007. The citation ratios for the Top 1% and Top 5% of all cited articles are large in relative percentages indicating these relatively small fractions of articles have had continuously high citation rates.*

Figure 78 illustrates (logarithmic scale) the publication and citation trend comparison that includes total articles and citations for the expanded Crops AND INDIA, INDIA with USA or INDIA with CHINA queries with all other countries excluded using the Analyst Tool. Also included for comparison are the total published articles in the period (1980-2006) for the INDIA (ONLY) query. Figure 79 shows the respective median citation for the Top 10 articles, average cites per article, and the average IF for the Top 10 journals (logarithmic scale).

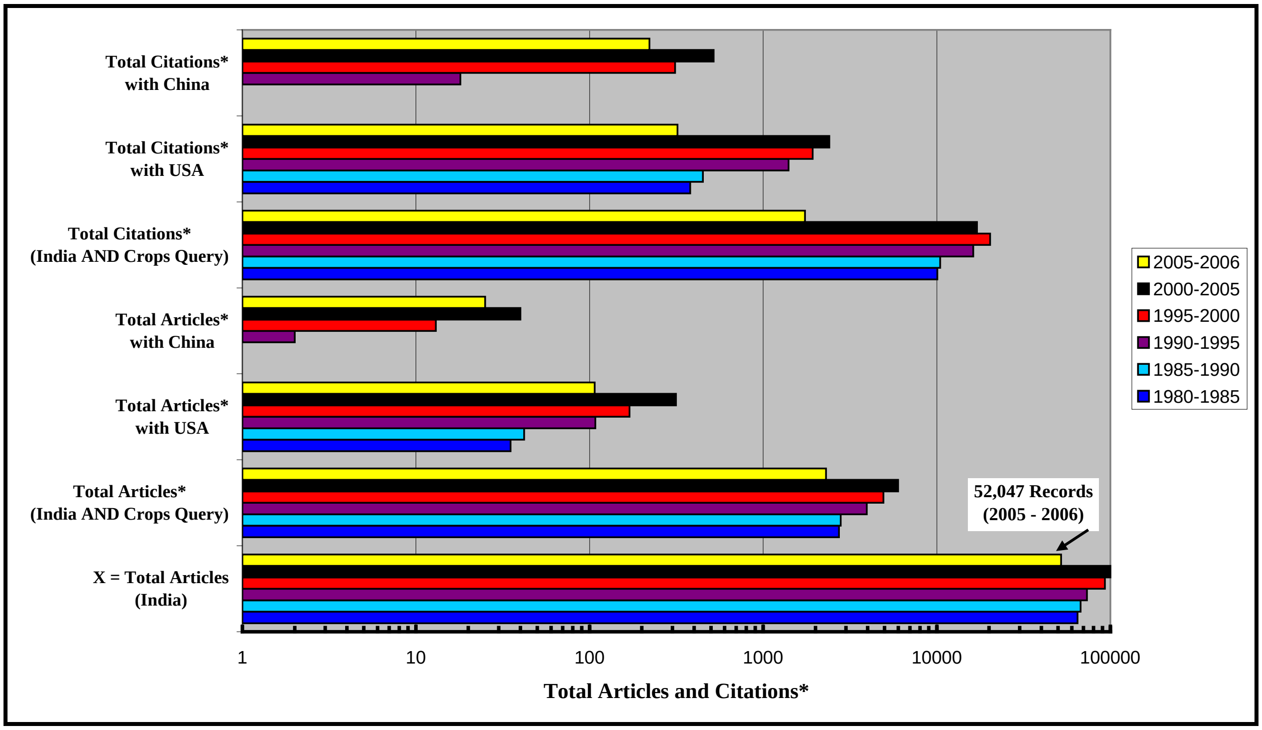

Figure 78. SCI/SSCI (1980-2006) Publication and Citation Trend Comparison Crops AND INDIA with (USA or CHINA) Query

Figure 78 illustrates several important factors worth noting:

- *The total articles retrieved using the India and thin film query (with USA and with China) for the period (1990- 2006) account for a significant percentage of the total records, when all other listed collaborating countries are considered and their contributing articles tallied. Note that no articles were retrieved for China during the period (1980-1990).*
- *The total articles and citations for (India with USA) always exceed (India with China).*
- *The total articles retrieved using the India and thin film query (with USA and with China addresses) and their relative total citations show a remarkable symmetry, that may be attributed to the relative journals and their associated impact factors, chosen by all three countries for research publication.*
- *The symmetry may not have been identified without the functions of the SCI/SSCI Analyst Tools that proved useful in excluding records from collaborating countries other than USA and China.*

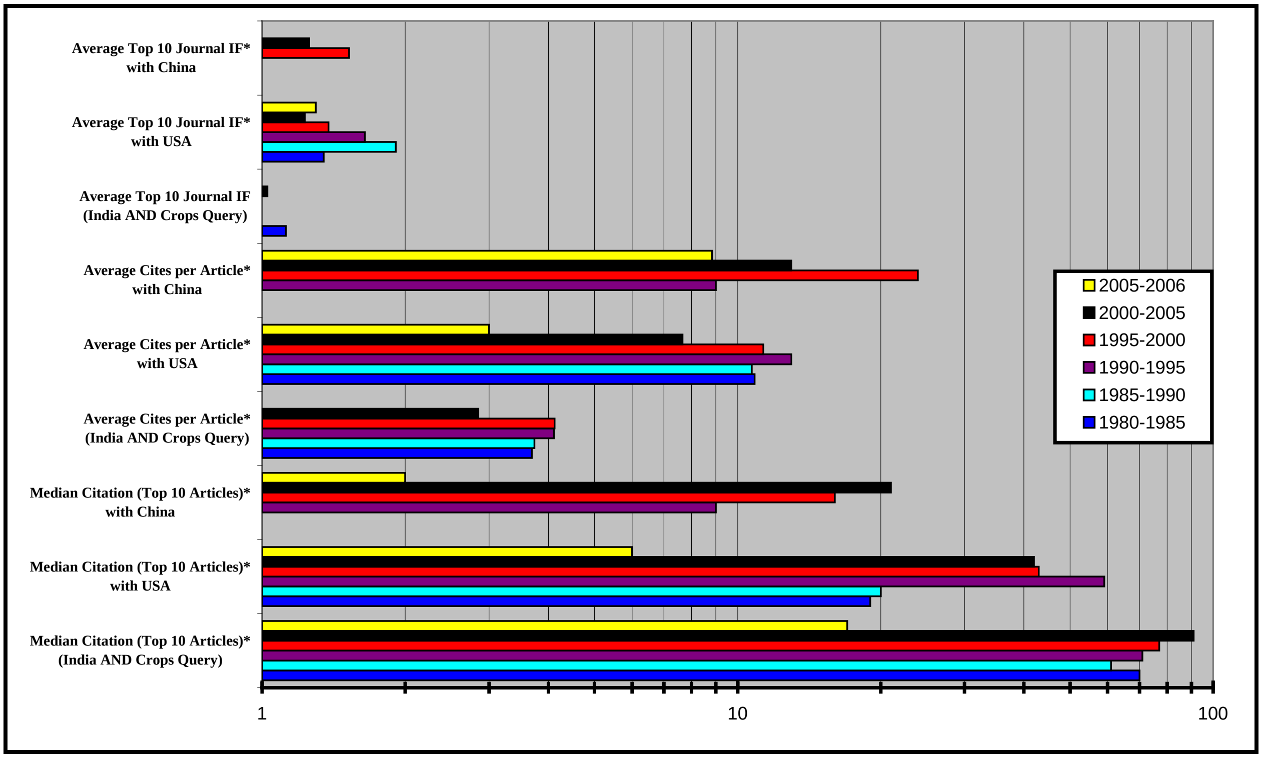

Figure 79. SCI/SSCI (1980-2006) Citation and Journal Impact Factor Trends Crops AND INDIA with (USA or CHINA) Query

Figure 79 illustrates several important factors worth noting:

- *The average cites per articles retrieved using the crops and India query show a significant increase with USA or with China, and all other country addresses excluded. This suggests that India collaborative research with USA or China is published in highly cited journals outside India, as evidenced by the average Top 10 Journal impact factors (IF) for all three countries. Note however that median cites of the Top 10 cited articles show an opposite trend.*
- *The average IF for the Top 10 journals using the crops and India query are less than one (1.0) for the periods (1985-2000) and (2005-2006) and are not shown on the log scale chart.*

4.3.2 Engineering Compendex (EC) Crops/Soil Research Collaboration Analyses

To develop comparative crops/soil bibliometric trend analyses for the Engineering Compendex (EC) database, articles for the period (1980-2006) were retrieved using the expanded Crops and INDIA address query. For each time interval (e.g., 80-85, 85-90, 90-95, etc.) the total articles retrieved were compared (by ratio) to the total articles published in the Top 10 Journals. In addition, the average Impact Factor (IF) for the Top 10 Journals was also calculated. Table 39 provides a summary of the EC bibliometric results in the same format as Table 37 above (SCI/SSCI results) for comparison.

TABLE 39. EC (1980-2006) PUBLICATION AND JOURNAL IMPACT FACTOR TRENDS (CROPS AND INDIA QUERY)

Engineering Compendex (EC)	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	629	824	626	913	2057	982
Top 10 Journal Records	214	341	168	371	769	337
Ratio (Top 10 Journal Records / Total Records)	0.340	0.414	0.268	0.406	0.374	0.343
Average Journal IF	0.178	1.639	1.332	1.340	1.234	1.496

Figure 80 illustrates the overall publication trend including the ratio of total articles to Top 10 Journal articles and average IF for each time interval. Note that the EC database contains only one author country address for each article; and that the database does not contain similar citation data, as compared to the SCI/SSCI database. Therefore, an identical comparative analysis of article citations could not be performed for the EC database.

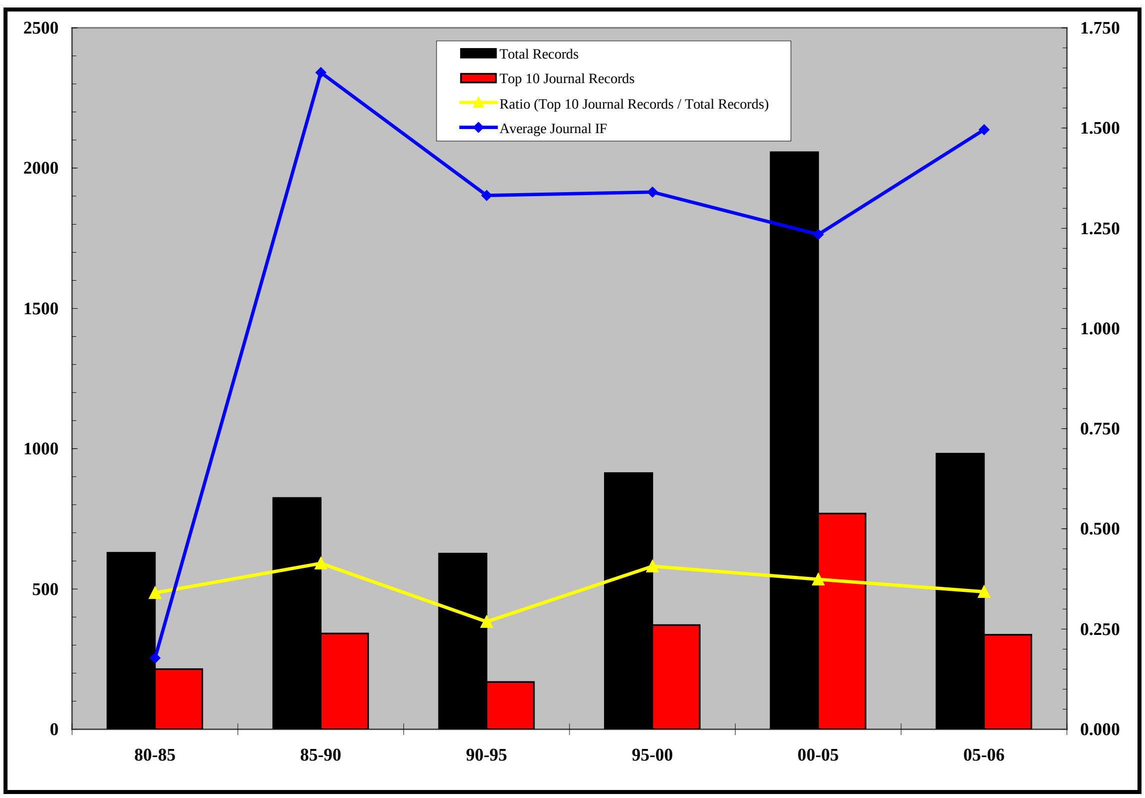

Figure 80. EC (1980-2006) Total Article and Average Top 10 Journal Impact Factors Publication Trend (Crops AND INDIA Query)

Figure 80 illustrates several important factors worth noting:

- *The total articles and Top 10 Journal articles show a significant increase for the period (1990-2005) compared to preceding periods (1980-1990).*
- *The ratio of articles published in the Top 10 Journals to total articles is essentially constant throughout the entire period (1980-2006).*
- *The average Top 10 Journal IF shows a significant recent increase from (2000-2006).*

4.3.3 INSPEC Crops/Soil Research Collaboration Analyses

To develop comparative crops/soil bibliometric trend analyses for the INSPEC database, articles for the entire period (1980-2006) were retrieved using the expanded Crops and INDIA address query. For each time interval (e.g., 80-85, 85-90, 90-95, etc.) the total articles retrieved were compared (by ratio) to the total articles published in the Top 10 Journals. In addition, the average Impact Factor (IF) for the Top 10 Journals was also calculated. Table 40 provides a summary of the INSPEC bibliometric results in the same format as Table 37 above (SCI/SSCI results) for comparison.

TABLE 40. INSPEC (1980-2006) PUBLICATION AND JOURNAL IMPACT FACTOR TRENDS (CROPS AND INDIA QUERY)

INSPEC	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**
Total Records	**192**	**136**	**189**	**186**	**338**	**220**
Top 10 Journal Records	**53**	**66**	**57**	**46**	**117**	**90**
Ratio (Top 10 Journal Records / Total Records)	**0.276**	**0.485**	**0.302**	**0.247**	**0.346**	**0.409**
Average Journal IF	**1.431**	**0.935**	**0.834**	**1.109**	**0.830**	**0.978**

Figure 81 illustrates the overall publication trend including the ratio of total articles to Top 10 Journal articles and average IF for each time interval. Note that the INSPEC database contains only one author country address for each article; and that the database does not contain similar citation data, as compared to the SCI/SSCI database. Therefore, an identical comparative analysis of article citations could not be performed for the INSPEC database.

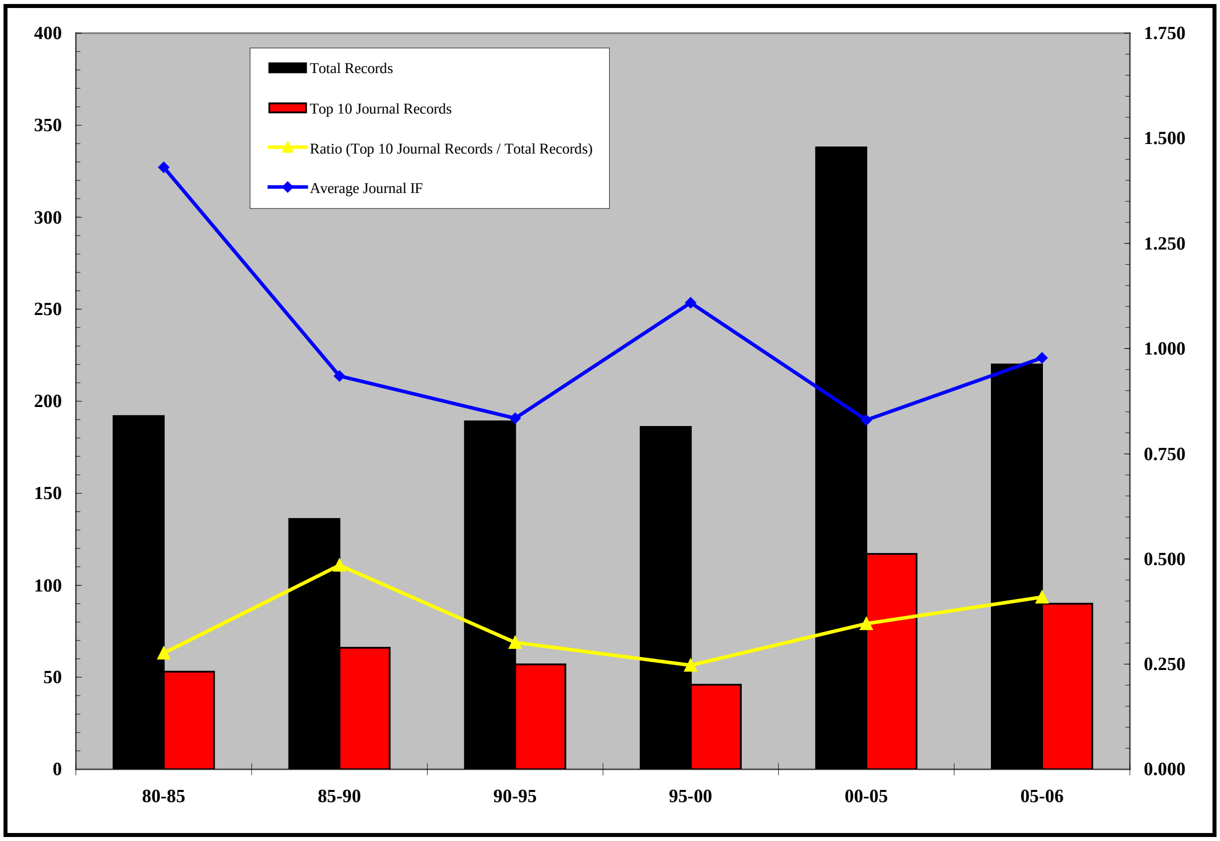

Figure 81. INSPEC (1980-2006) Total Article and Average Top 10 Journal Impact Factors Publication Trend (Crops AND INDIA Query)

Figure 81 illustrates several important factors worth noting:

- *The total articles and Top 10 Journal articles show a significant increase for the period (1990-2005) compared to preceding periods (1980-1990). Note the magnitude of total articles for the period (2005-2006) relative to the intervals comprising the period (1980-2000).*
- *The ratio of articles published in the Top 10 Journals to total articles is essentially constant throughout the entire period (1980-2006).*
- *The average Top 10 Journal IF is also constant throughout the entire period (1980-2006).*

4.3.4 Comparative Database Thin Film Collaboration Analyses

Table 41 provide a comparative listing of the total articles retrieved using the Crops and India query and total articles retrieved using the India address (ONLY) query from the SCI/SSCI, EC and INSPEC databases for the period (1980-2006). Table 41 also lists the respective ratio of total articles retrieved using the Crops and India query, and total articles retrieved using the India address (ONLY) query for each database. Figure 82 illustrates the overall publication trends for total articles, and Figure 83 illustrates the respective ratios for each database (including Grand Total for all three databases) for the entire period (1980-2006).

TABLE 41. SCI/SSCI, EC AND INSPEC (1980-2006) COMPARATIVE TOTAL PUBLICATION TREND (CROPS AND INDIA QUERY) / (INDIA ONLY)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06	80-05
SCI/SSCI Total Records (India Only)	64600	67416	73202	92909	100000	52047	398127
SCI/SSCI Total Records (Crops AND India)	2729	2794	3949	4929	5,980	2,300	20381
SCI/SSCI Total Record Ratio (Crops AND India / India)	0.042	0.041	0.054	0.053	0.060	0.044	0.051
Engineering Compendex (EC)	80-85	85-90	90-95	95-00	00-05	05-06	80-05
EC Total Records (India Only)	22728	22941	20104	31735	53505	25304	151013
EC Total Records (Crops AND India)	629	824	626	913	2057	982	5049
EC Total Record Ratio (Crops AND India / India)	0.028	0.036	0.031	0.029	0.038	0.039	0.033
INSPEC	80-85	85-90	90-95	95-00	00-05	05-06	80-05
INSPEC Total Records (India Only)	28506	30606	33246	34624	45171	20860	172153
INSPEC Total Records (Crops AND India)	192	136	189	186	338	220	1041
INSPEC Total Record Ratio (Crops AND India / India)	0.007	0.004	0.006	0.005	0.007	0.011	0.006

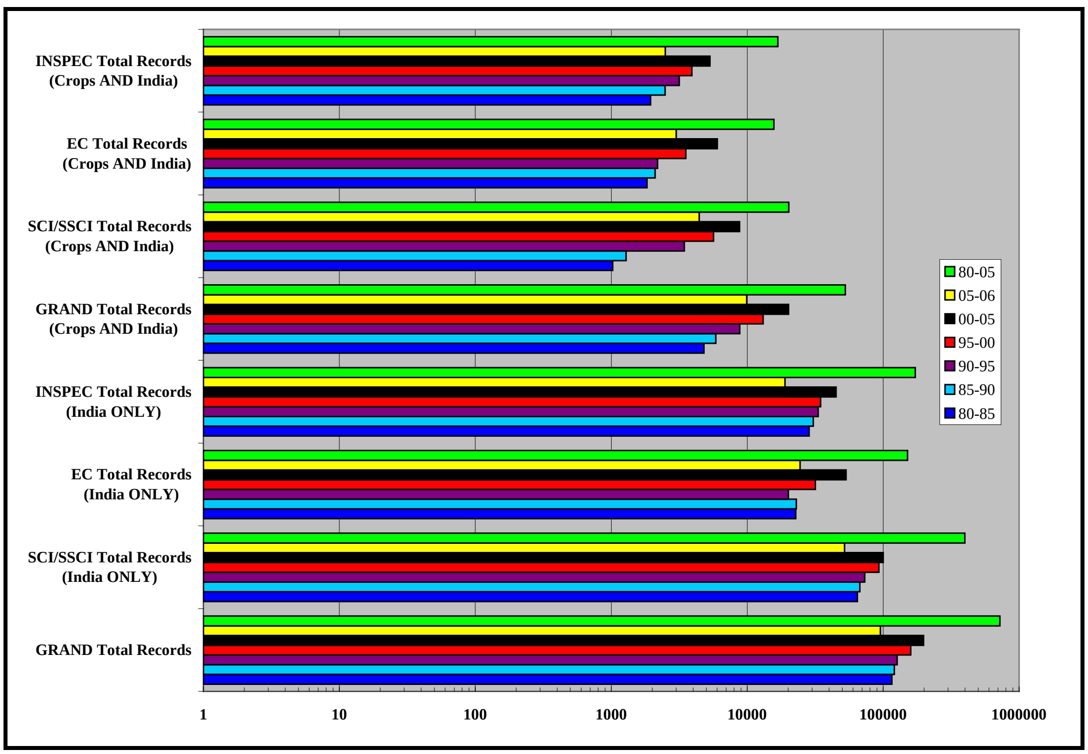

Figure 82. Comparative Total Article Publication Trend (1980-2006) (Crops AND India Query) / (India ONLY)

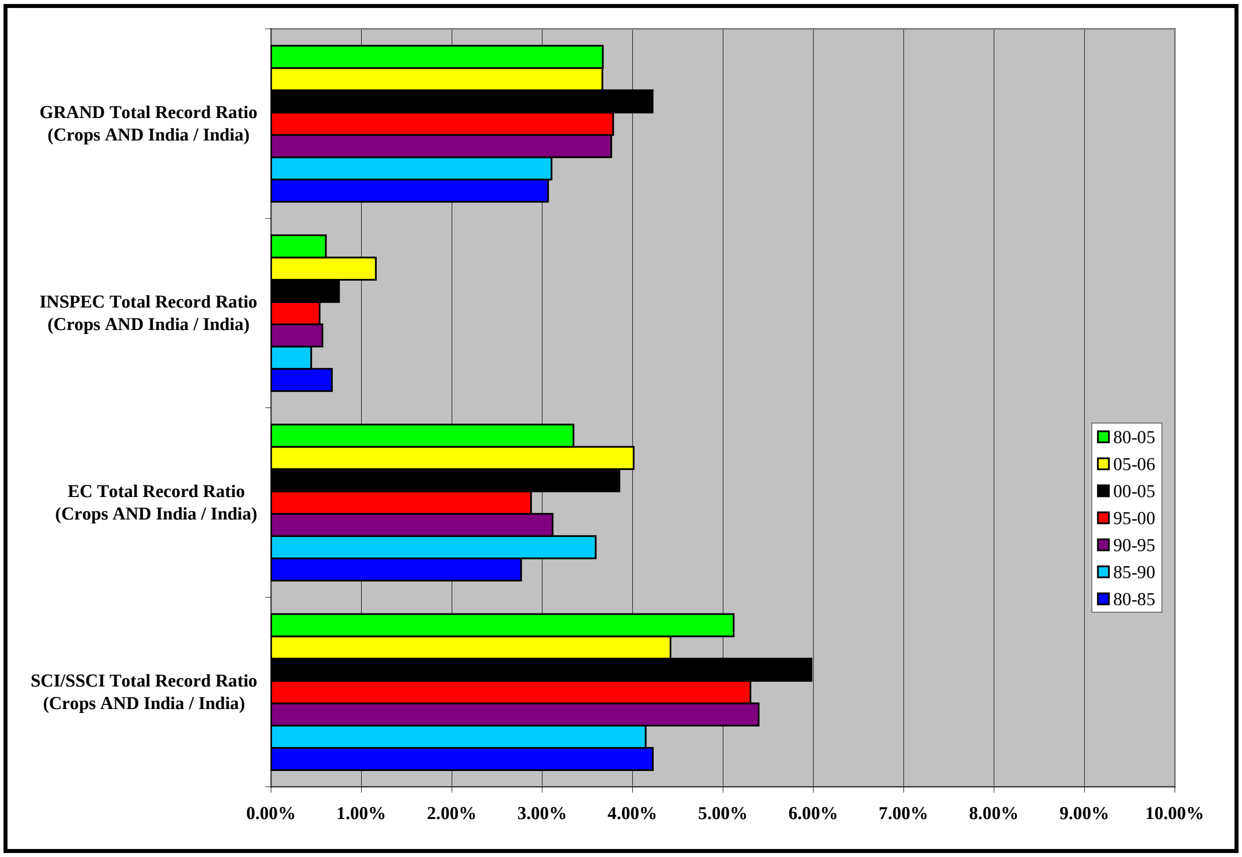

Figure 83. Comparative Total Article Ratio Publication Trend (1980-2006)
(Crops AND India Query) / (India ONLY)

Table 42 combines Table 27, Table 39, and Table 40 listed above to provide a comparative listing of the total article publication and average Top 10 Journal IF Trends for the SCI/SSCI, EC and INSPEC databases for the period (1980-2006) using the crops AND INDIA address query. Figure 84 graphically illustrates the overall publication trends for each database.

TABLE 42. COMPARATIVE TOTAL PUBLICATION AND AVERAGE TOP 10 JOURNAL IF TRENDS (SCI/SSCI, EC AND INSPEC (1980-2006)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06	80-05
Total Records	2729	2794	3949	4929	5980	2300	19059
Top 10 Journal Records	1237	1156	1500	2058	2171	705	6,889
Ratio (Top 10 Journal Records / Total Records)	0.453	0.414	0.380	0.418	0.363	0.307	0.361
Average Journal IF	1.057	0.556	0.625	0.833	1.072	1.052	0.990
Engineering Compendex (EC)	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**	**80-05**
Total Records	629	824	626	913	2057	982	5063
Top 10 Journal Records	214	341	168	371	769	337	1411
Ratio (Top 10 Journal Records / Total Records)	0.340	0.414	0.268	0.406	0.374	0.343	0.279
Average Journal IF	0.178	1.639	1.332	1.340	1.234	1.496	1.340
INSPEC	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**	**80-05**
Total Records	192	136	189	186	338	220	1261
Top 10 Journal Records	53	66	57	46	117	90	429
Ratio (Top 10 Journal Records / Total Records)	0.276	0.485	0.302	0.247	0.346	0.409	0.340
Average Journal IF	1.431	0.935	0.834	1.109	0.830	0.978	1.224

Table 42 indicates several important factors worth noting:

- The total articles published in all databases show a significant increase for the period (1980-2005). The SCI/SSCI total publications significantly exceed EC and INSPEC total publications.
- The ratio of Top 10 Journal articles to total articles is essentially constant throughout the entire period (1980-2006) for all three databases.
- The average journal impact factor (IF) for both EC and INSPEC databases were normally higher compared to the SCI/SSCI database, however there is a notable increase in SCI/SSCI average journal IF for the period (1985-2006).

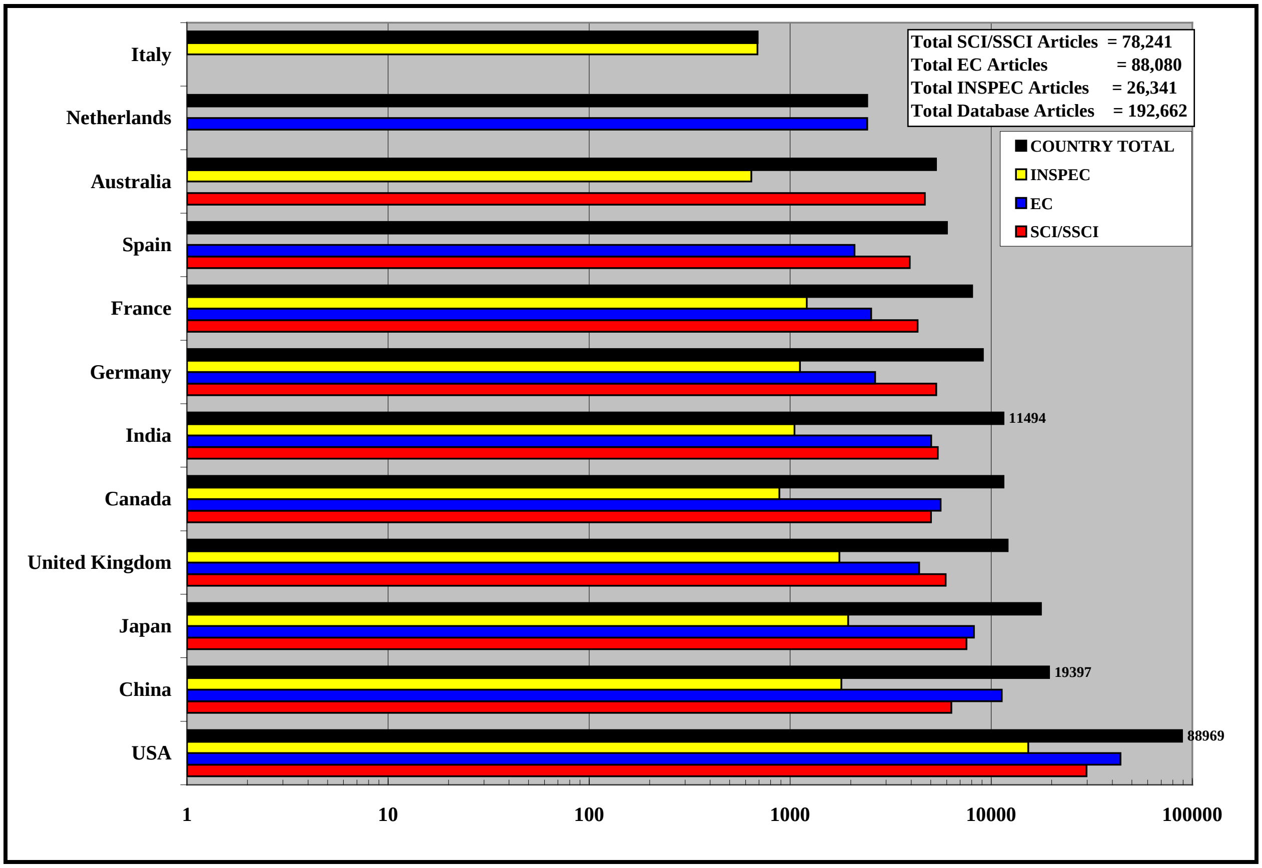

Figure 84. Comparative Country Thin Film Publication Trends (1980-2006)
Crops (ONLY) Query

Figure 84 illustrates several important factors worth noting:

- The total number of combined countries ranked in the Top 10 in each database =12.
- The total publications in the SCI/SSCI database (78,241 articles) and EC (88,080 articles) database are comparable. The low number of publications from the INSPEC database may reflect the more technical nature of subject coverage compared to SCI/SSCI and EC databases. The total publications from all databases equaled 192,662 articles (1980-2006).
- The USA as the leader in total publications in all databases (ranked 1st @ 88,969 articles) over the entire period.
- The total publications for the Peoples Republic of China (ranked 2nd @ 19,397 articles), is approximately 22% of the total for the USA.
- The total publications for India (ranked 6th @ 11,494 articles), is approximately 13% of the total for the USA. Thus, from a global perspective, India is prominent, in terms of both indigenous and collaborative thin film research output, and ranked highly in the Top 10 nations. Analysis provided above indicated that the predominant countries collaborating with India on crops/soil (agronomy) research over this period include in order; USA, Germany, United Kingdom, South Korea, Australia, Peoples R China (2nd in publications), Philippines, Japan, France, and Netherlands.

The articles retrieved using the expanded crops AND INDIA address query from all databases indicates that India is conducting crops/soil research for a wide breadth of applications. A similar analysis, as for thin films, using author affiliation auto-correlation maps data to identify what specific research institutions, laboratories, universities or industry are ***currently*** involved in crops/soil (agronomy) research. The EC and INSPEC author affiliation auto-correlation maps do not display collaboration groups (linkages), therefore only the SCI/SSCI auto-correlation map is provided in Figure 85 that depicts moderately connected publishing groupings or intra-connection within several groups centered on the following affiliations:

- Indian Council for Agriculture Research (ICAR) – 84 Laboratories
- India Institute of Technology (IIT) – 7 Institutes

Prominent Indian (indigenous) crops/soil research focus areas and publication topics were identified using two sources of information: 1) Research article titles extracted from author affiliation auto-correlation maps; and 2) Research article titles provided by the CLUTO clustering algorithm for all. As displayed in Figure 85, ICAR and IIT show numerous linkages to other major universities including, Tamil Nadu Agricultural University and the University of Delhi. As such, a sampling of research articles attributed to ICAR and IIT were selected for further analysis discussed below to identify prominent crops/soil focus areas and publication topics. A sampling of research articles were retrieved, sorted based on total times cited, and then analyzed to determine principal research focus areas. In addition, due to the large number of titles, only a sampling were analyzed from database taxonomy leaf clusters

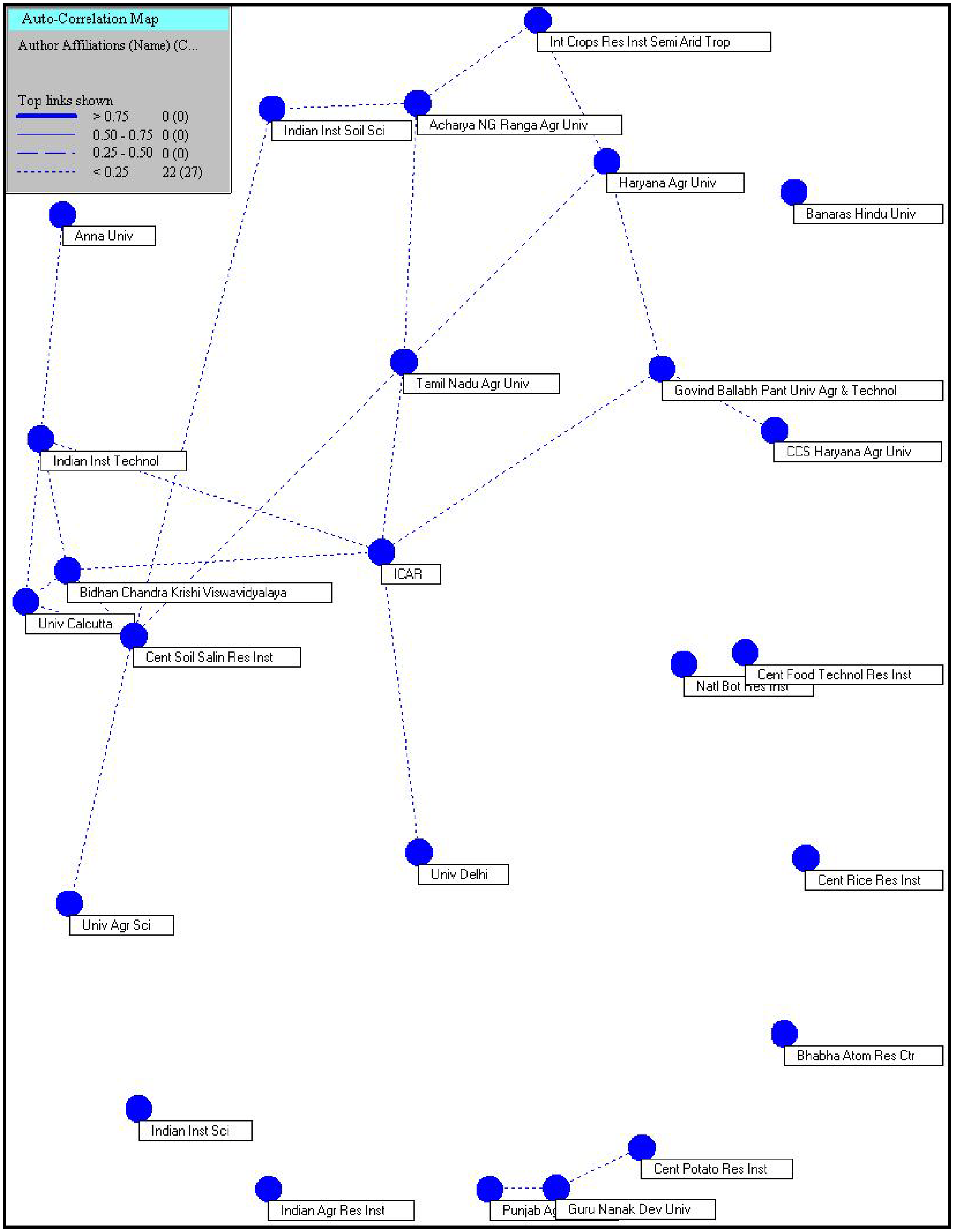

Figure 85. SCI/SSCI (2005-2006) Top 25 Author Affiliations Auto-correlation Map (Crops AND INDIA Query)

- Prominent indigenous crops/soil research focus areas and publication topics were identified for articles containing India addresses only including:

  1. The map-based sequence of the rice genome is being investigated under the International Rice Genome Sequencing Project. Rice, one of the world's most important food plants, has important syntenic relationships with the other cereal species and is a model plant for the grasses. The map-based sequence has proven useful for the identification of genes underlying agronomic traits and could accelerate improvements in rice production.
  2. Case studies to assess the long-term effect of sewage irrigation on heavy metal content in soils, plants and groundwater. The gradual decline in availability of fresh water to be used for irrigation in India demands the use of sewage and other industrial effluents for irrigating agricultural lands.
  3. Development of separation and purification technology for removal and recovery of malachite green from wastewater using an agricultural waste material, de-oiled soya. De-oiled soya is a waste product obtained during the processing of soyabean in soya oil extraction mills. Attempts are being made to exploit this crop as waste material and low cost adsorbent for the removal of toxic textile dye 'malachite green'.
  4. Bottom ash, a power plant waste, and de-oiled soya, an agricultural waste material, is also being used for removal and recovery of *Amaranth* and Quinoline Yellow water-soluble *hazardous* dyes.
  5. Changes in antioxidant enzyme activity and oxidative stress by abscisic acid and salicylic acid in wheat genotypes is being investigated. The beneficial effect of increase in antioxidant enzymes activity and decrease in oxidative stress is reflected in increase in chlorophyll and carotenoid contents, relative water content, membrane stability index, leaf area and total biomass over control plants.
  6. Investigations of population density and low nitrogen affects on yield-associated traits in tropical maize. Tolerance to high plant population density has been proposed as an alternative breeding strategy to improve stress tolerance in maize and better understanding of mechanisms underlying tolerance to high plant population density is required. Studies indicate the effect of stress on yield components and the strength of association between secondary traits and yield varied greatly according to germplasm type.
  7. Experiments on commercial potato cold storage are evaluating operating and geometric parameters (e.g., loading density, percentage free space, potato temperature during cooling, cool-down time, storage air temperature and humidity, loading pattern, power consumption pattern, heat transfer coefficients in evaporator and condenser) related to the losses of stored produce.

- Prominent crops/soil research focus areas and publication topics were identified for articles containing both India and China addresses including:

  1. Collaboration on the International Rice Genome Sequencing Project to investigate the map-based sequence of the rice genome (see above).
  2. Collaboration on the Tomato Sequencing Project, the first cornerstone of the International Solanaceae Project (SOL) (see above).

3. Investigation of water saving for sustaining and increasing the productivity of rice-wheat systems. Current technologies for reducing irrigation water requirements include laser leveling, direct drilling, raised beds, non-ponded rice culture and irrigation scheduling. Studies indicate that rehabilitation and improvement of canal and power systems in Asia are required to facilitate adoption of many water saving technologies.

- Lastly, prominent crops/soil research focus areas and publication topics were identified for articles containing both India and USA addresses including:

1. Collaboration on the International Rice Genome Sequencing Project to investigate the map-based sequence of the rice genome (see above).
2. Collaboration on the Tomato Sequencing Project, the first cornerstone of the International Solanaceae Project (SOL) (see above).
3. Investigation and modeling of Greenhouse gas emissions (simulate methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2)) from Indian rice fields using various management practices. The study suggested models could be applied for estimating the gas emissions and the influences of agronomic management, soil and climatic parameters.
4. Investigations of the adoption of bacillus thuringiensis (Bt) cotton and impact variability, based on insights from India. There is a growing body of literature on the impacts of Bt cotton in developing countries, and these studies focus on explaining paradoxes in recent controversy over genetically modified crops. The studies indicate that apart from differences in pest pressure and patterns of pesticide use, germplasm effects can play an important role. Theoretical arguments were supported by empirical evidence from India.

4.3.5 Conclusions: Extended India Research Collaboration Analyses – Crops/Soil

The extended crops/soil collaboration analyses provided useful information regarding the objective questions listed above as follows:

- The extent (scope) of Indian crops/soil research in terms of overall output production in a given period (1980-2006) is determined by the total publication trends. These trends further indicate a steady publication growth rate during the entire period (1980-2006).

- The extent of India crops research collaboration with both the USA and China in terms of overall output production in a given period (1990-2006), is determined by the total publication trends. The total publication and article citation trends show steady growth rates during the entire period.

- Collaborative crops/soil research with USA and China authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to indigenous research being published by only India authors.

- Primary collaborating countries other than the USA or China identified from the SCI/SSCI database for the entire period (1980-2006) include United Kingdom, Philippines, Germany, Australia, Japan, Canada, and Netherlands.

- The utility of India crops/soil collaborative research as related to article citations and associated Journal impact factors has been addressed. The collaborative research is published in higher cited journals, with greater average cites per article and impact factors compared to research being published with only India authors. However, the ratio of total citations for the Top 1% and Top 5% of the most cited articles retrieved to total citations of ALL articles shows a dramatic growth rate for the period (2005-2006). The citation rate for the Top 1% and Top 5% of these articles is extremely high in comparison to the entire preceding period (1980-2005), suggesting that the overall growth rate and utility of crops research within India is increasing and is being recognized and cited by international researchers.

- The overall taxonomy of crops/soil research (indigenous and collaborative) in terms of predominant generalized subject categories comprises agronomy, plant sciences, microbiology and biotechnology, environmental biology, genetic resources and crop evolution, and food processing technology.

- The present data mining tools and resources (workstation and database levels) used within the present study are adequate to produce useful information from a realm of data. Several of the bibliometric trends over the period exhibited remarkable symmetry that may not have been identified without the functions of the SCI/SSCI Analyst Tools. Refinements to the overall processing of raw records should be considered as certain improvements are required in handling large record datasets and huge memory files, for computers other than the dedicated data mining workstations at the Office of Naval Research (ONR). Currently, the processing time for records and files on computer laptops is lengthy, and software upgrades to the TechOasis Package are mandatory for future data mining studies conducted at remote locations other than ONR.

4.4 Extended India Research Collaboration Analysis - Subject Categories

The results of analyses described above in Section 3.4 provided gross bibliometrics and brief overviews of the collaborative nature of India research (based on co-authorship) with the USA and Peoples Republic of China. Specifically, Tables 19 and 20 provided information on the Top 25 Journals, Author Affiliations and Subject Categories. Likewise, the results of document clustering analyses described above in Section 4 identified select single technology focus areas that were further analyzed to establish a keener perspective and more detailed overview of the collaborative nature of India research with the USA and Peoples Republic of China. Specifically, the extended India collaboration analyses for both thin films and crops/soil research provided bibliometric information on the Top 10 Journals, Author Affiliations and Subject Categories, and other Countries listed with India addresses. The collaboration analyses also established detailed output (article publication) and citation trends for the period (2005-2006), and the extended period (1980-2005) by intervals, for the SCI/SSCI, EC and INSPEC databases. The combined single technology (thin films and crops/soils) analyses demonstrated some interesting and at times dramatic results addressing the impact (effects) of collaboration on the overall regarded utility of the research based on article citations and associated Journal impact factors. The final analysis described below is intended to provide a final perspective of the nature of India collaborative research with the USA and Peoples Republic of China (China). Specifically, the analysis uses several Country address queries to determine if these effects are evident across a much broader, generalized taxonomy of India research, as opposed to the single-technology level.

4.4.1 Review of Related India Research Collaboration Analyses

International collaboration is becoming an increasingly significant issue related to science policy and the publication of S&T research literature. For analyzing the many aspects of international research collaboration, bibliometrics methods are commonly used to determine the nature (scientific activity), level of participation of specific countries and impact on performance in different fields. For such analyses, co-authorship in publications is being used as a proxy for collaboration. The impact of the co-authored articles is evaluated through the impact factor (IF) of the reporting journal. Recent bibliometric studies of co-authorships in publications have focused on both bilateral and multilateral research, in attempts to reveal general patterns of collaboration impact. To provide a framework for the present analysis, five (5) research articles that provided related India research collaboration studies performed within the period (2000-2007) are summarized below.

4.4.1.1 Study 1: "International Collaboration in Indian Scientific Papers"

In this study (Ref: 10), published research output was retrieved from the SCI/SSCI database for the years 1990 and 1994 containing at least one author with an India address. The co-occurrence of a pair of countries listed in the address field was regarded as a single collaborative link. The total records retrieved for 1990 equaled 10,103 with 1,334 collaborative links (13.2 links/per 100 articles). The total records retrieved for 1994 equaled 11,314 with 2,111 collaborative links (18.7 links/per 100 articles).

The results of the study indicate the main collaborative partner was the USA accounting for more than one-third (1/3) of the total links. Other major partners included Germany, UK, Japan and Canada. Physics, Medicine, Biomedical research and Biology were the predominant disciplines. The study also indicates that *although India had a relatively large indigenous publication output compared to other countries of interest, the extent of collaboration (inversely proportional to the size of indigenous output) was lower then expected. For the period (1990-1994), the total co-authored research articles from India increased by 40% (less than the growth rate of collaborative articles worldwide).* Lastly, the results indicated the emergence and impact of collaboration with several developing countries in South Asia, for which the total co-authored research articles with India increased by 200%.

4.4.1.2 Study 2: "Mapping International Collaboration in Science in Asia through Co-authorship Analysis"

In this study (Ref: 11), published research output, comprising full-length articles, reviews and notes, was retrieved from the SCI/SSCI database for the year 1998 containing any of the following country addresses: India, China, Japan, South Korea, Taiwan, Hong Kong, Singapore, Thailand, Malaysia, Indonesia and Philippines. Output having more than one country address was identified and an internationalization index, based on the number of international linkages, was calculated for each country where:

Internationalization Index = 100 × (number of international links / total number of papers)

The results indicated that Japan (16.4% of internationally collaborated papers), India (17.6%) and Taiwan (16.3%) recorded an internationalization index less than 30; whereas China (28.5%), South Korea (24.6%) and Hong Kong (36.2%) recorded an internationalization index greater than 40. Japan, with over 60,000 papers, was second only to the USA in the total number of papers published. China (11th), India (14th) and South Korea (15th) were the only other Asian countries ranked in the Top 15 research output producers.

The results also indicated that *Japan and India, both countries with relatively low overall growth rates of international collaboration, shared 46% and 40%, respectively of their co-authored papers with the USA. For other Asian nations, collaboration rates with the USA ranged from 70% for Taiwan to 31% for Singapore*. Lastly, the results indicated India, China and South Korea collaborated extensively in physics, whereas the other eight countries collaborated more in life sciences. *In almost all fields of research, USA was the most preferred collaborating partner; and all G7 countries collaborated more with China, which was identified as the emerging leader in regional collaboration, compared to India.*

4.4.1.3 Study 3: "International Collaboration in Science in India and Its Impact on Institutional Performance"

In this study, (Ref: 12) published research output of major Indian institutions was retrieved from the SCI/SSCI database for the year 1997 containing at least one author with an India address. Research articles containing no address originating outside India were regarded as indigenous publication output, and the total indigenous and collaborative (international) output of each institution was compiled. The data was then used to determine if research performance, in terms of average journal impact factor (IF), depend critically on international co-authorship.

This study provides *results of previous India research bibliometric analyses indicating there has been an overall increase in collaborative articles as well as partner countries in the early 1990's. The largest number of co-authored articles was attributed to USA and Germany; however, there had also been an increase in collaboration with countries in the Asian region. The study also indicates that internationally co-authored articles are known to have significantly higher IF compared to indigenous articles; and that the contribution of such articles to the average IF of the institutional output could be disproportionately high.*

To quantify this effect, an index of "gain in impact through foreign collaboration" (GIFCOL) was first defined for each institution, where:

GIFCOL = 100 x (Cumulated Impact of Internationally Co-authored Articles / Cumulated Impact of all Articles) –
100 x (Number of Internationally Co-authored Articles / Total Articles)

GIFCOL was defined to take into account the proportion of articles that are collaborative, and measures the difference between this and the corresponding proportional gain in impact. Clustering analyses were then performed to group and rank large and medium institutions based on characteristics including total publication output, proportion of collaborative research articles, impact factor of indigenous and collaborative articles, and gain in impact through collaboration. Statistical analysis is then used to distinguish intrinsically high performance institutions, and those that gain disproportionately in terms of perceived quality of their output due to international collaboration.

The results of this study identified private hospitals as institutes that gained most strongly from foreign collaboration, in contrast to the reputed government funded Medical Institute in Delhi, which had a very high IF for its indigenous articles, comparable to the impact of foreign articles. *Universities were determined as not having collaborated to large extent, and had comparable IF values for both indigenous and collaborative articles. Only a small number of Universities were indicated as having gained disproportionately from collaboration, such as Panjab University. The institutes categorized as constituting the core of Indian science did also not gain disproportionately through collaboration.* The core group comprised 18 Institutions with 5 Research Institutes, 5 Universities, 5 Institutes of Technology (IIT's) and 3 medical institutes or hospitals. *The Tata Institute of Fundamental Research was identified as the star performer in the Indian context, based on very high productivity, and significant comparable gain in impact through collaboration*.

4.4.1.4 Study 4: "India's collaboration with People's Republic of China in Science and Technology: A Scientometric Analysis of Co-authored Papers during 1994-1999"

In this study (Ref: 13), the collaborative research between India and People's Republic of China is analyzed, based on the co-authored research articles retrieved from the SCI/SSCI database for the period (1994-1999). The objective of the study was to investigate the nature, level of participation, technical strength areas, and overall impact of the collaboration in different subject categories. It should be noted that the overall analysis objectives and approach presented in the referenced study are essentially identical to those of the present study for the period (2005-2006). The results of the study indicates a *growing collaboration between India and People's Republic of China based on the increase in number of co-authored articles from 1994 (21) to 1999 (74). It was also determined that S&T collaboration between is established mainly through multilateral channels with other partner countries; the output through bilateral channels is very small (11.7%).*

Physics (nuclear and particle) and Clinical Medicine were the priority subject categories accounting for 62% and 14% of the total research publications, respectively. *The average journal IF of all co-authored articles equaled 2.77. The average IF of articles under multilateral research equaled 2.94. This higher impact was attributed to the participation of other advanced and developing countries, and to larger participation of institutions per article. The average IF of articles under bilateral research equaled 1.45, a lower value compared to multilateral articles.* Lastly, the study identifies specific subject categories with potential to leverage the collaboration, particularly at the bilateral level.

4.4.1.5 Study 5: "Bibliometric Indicators of Indian Research Collaboration Patterns: A Correspondence Analysis"

In this study (Ref: 14), India research output as given in multi-authored publications was retrieved from the SCI/SSCI database for the period (1993-2000). The retrieved records were classified into 23 different subject categories. The top ten collaborating countries in each category were extracted, and similarly these countries' collaboration in other categories were also extracted. Correspondence analysis was used to identify and visualize the association between two or more categorical variables, and reveal category/country collaboration patterns of India research publications. The correspondence analysis was performed using freeware known as DTM (Data and Text Mining) software (available at http://www.lebart.org).

The results of the correspondence analysis indicated *Physics, Chemistry, Clinical medicine predominant subjects reflecting international collaboration. USA, Italy, Germany, France, and England were the Top 5 countries collaborating with India.* The results of the analysis also indicated a collaborative pattern of India research with the following associations:

- *Physics (Italy, Switzerland, Algeria, Finland, South Korea, Russia, Netherlands)* contrasting an association between Clinical Medicine, Biology and Biochemistry, Immunology, Ecology and Environment, Geosciences, Multidisciplinary subjects (England, Japan, Canada).
- *Agriculture (Philippines, Canada, Denmark)* contrasting an association between Chemistry (Malaysia, Germany, France).
- Clinical medicine, Astrophysics (England, Sweden, USA, New Zealand).
- Engineering, Mathematics, Computer Science, Neuroscience (Singapore, Canada, USA) contrasting an association between Chemistry, Astrophysics (Malaysia, Spain).

4.4.2 Collaboration Analysis Approach and Results

The analysis was conducted by initially using the INDIA address (ONLY) query to identify the prominent Subject Categories assigned by the SCI/SSCI database for the period (2000-2007). This period was selected to provide current information, and allow sufficient time for citation data to accumulate, and be recorded. Since the analysis required detailed article citation data, the EC and INSPEC databases cannot be included for comparison. For comparison, the analysis then used USA (ONLY) and China (ONLY) address queries to retrieve all articles in order to identify the Top 20 Subject Categories that coincide for India, USA and China. Finally, the SCI/SSCI Analyst Tool was used to exclude other Country addresses to retrieve all articles with both (India with USA) and (India with China) addresses for the same identical Top 20 Subject Categories. Output and citation data for these five sets of articles were then generated to establish comparative output publication trends and to determine the effects of collaboration on citations across the generalized taxonomy of India research encompassed by the Top 20 Subject Categories. Article citation data comprised total and average cites, in addition to the median citation of the Top 10 cited articles (from total articles and from Top 10 cited Journals) for each subject category. It should be noted that although the select Top 20 Subject Categories used in this basic analysis encompass only a portion of the total categories that could be included. It should also be noted that each article may contain multiple subject categories, therefore there is overlap in the summation of total number of articles (70,055) over all 20 categories. The actual total number of unique articles contained within the Top 20 Subject Categories equaled 55,993 representing a significant percentage (56%) of the total number of articles retrieved (99,956) using the India (ONLY) query. Table 43 provides a listing of the total research articles retrieved for each Top 20 Subject Category and Country address query.

TABLE 43. TOTAL ARTICLES FOR TOP 20 SUBJECT CATEGORIES / COUNTRY ADDRESSES

Rank	Total Articles Top 20 Subject Categories (2000-2007)	India	China	USA	India with China	India with USA
1	BIOCHEMISTRY & MOLECULAR BIOLOGY	4484	3809	5816	30	403
2	BIOTECHNOLOGY & APPLIED MICROBIOLOGY	2465	1778	1620	10	121
3	CHEMISTRY, APPLIED	1786	2009	0	3	55
4	CHEMISTRY, INORGANIC & NUCLEAR	2395	2403	0	25	215
5	CHEMISTRY, MULTIDISCIPLINARY	6318	5495	1751	13	154
6	CHEMISTRY, ORGANIC	6013	2275	1281	11	208
7	CHEMISTRY, PHYSICAL	5630	6087	1913	22	268
8	CRYSTALLOGRAPHY	2221	3646	0	10	146
9	ENGINEERING, CHEMICAL	3092	2434	712	8	75
10	ENGINEERING, ELECTRICAL & ELECTRONIC	2799	3811	3179	29	271
11	ENVIRONMENTAL SCIENCES	2730	2403	2240	22	127
12	MATERIALS SCIENCE, MULTIDISCIPLINARY	6946	8838	2411	36	357
13	METALLURGY & METALLURGICAL ENGINEERIN	1628	3932	0	8	87
14	PHARMACOLOGY & PHARMACY	2899	2289	2410	14	173
15	PHYSICS, APPLIED	3522	6110	2842	36	219
16	PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	2167	1693	1182	5	149
17	PHYSICS, CONDENSED MATTER	3958	3500	1474	26	237
18	PHYSICS, MULTIDISCIPLINARY	3822	5462	1162	270	466
19	PLANT SCIENCES	2382	1905	1223	25	135
20	POLYMER SCIENCE	2798	3382	609	20	85

Figure 86 (linear scale) illustrates the comparative subject category publication trends for India, USA and China, and Figure 87 (log scale) illustrates the comparative publication trends for India with USA and India with China, respectively.

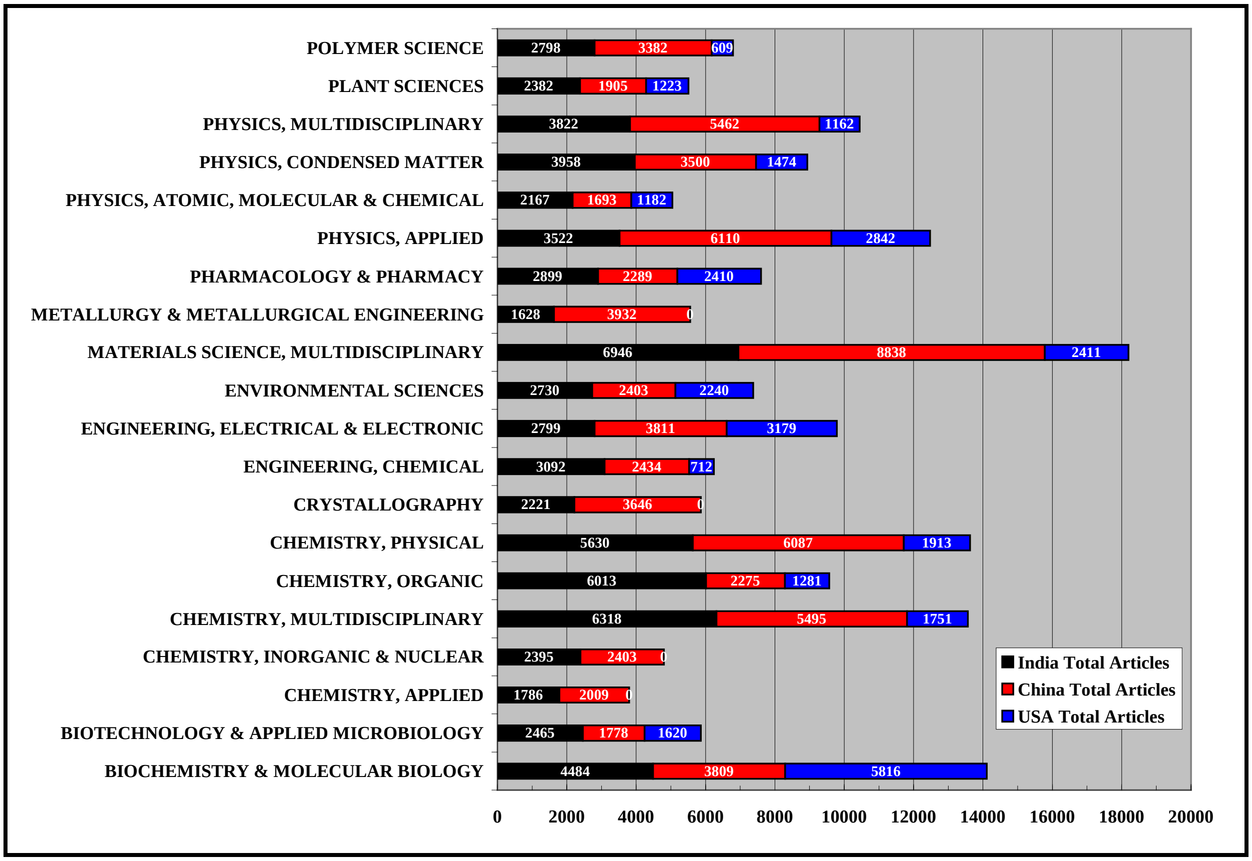

Figure 86. Comparative Category Publication Trends for India, USA and China

Figure 86 illustrates several important factors worth noting:

- Materials Sciences; Chemistry; Biochemistry and Molecular Biology; and Applied Physics are the predominant categories for India, USA and China.
- USA's only dominant category is Biochemistry and Molecular Biology.
- India and China have a similar distribution of total articles between categories.

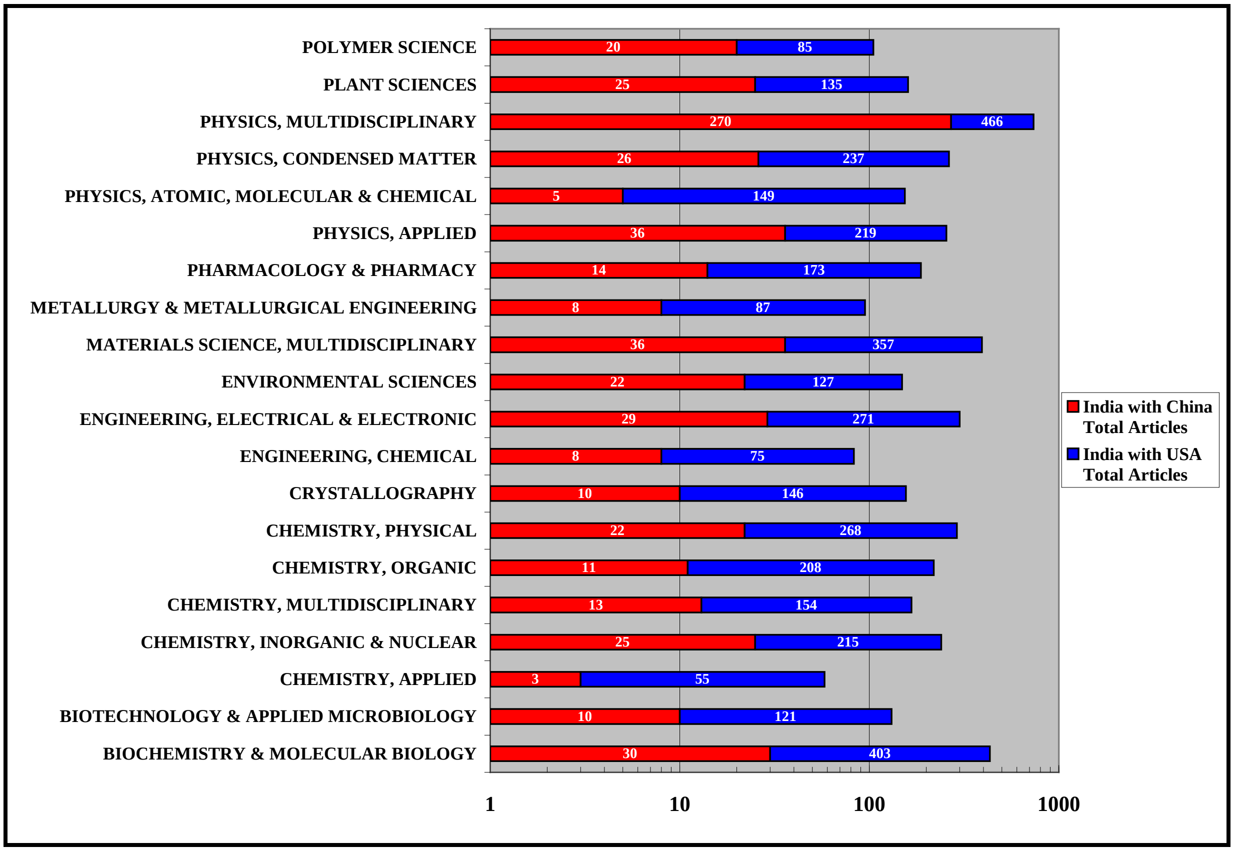

Figure 87. Comparative Category Publication Trends for India with USA and China

Figure 87 illustrates several important factors worth noting:

- There is essentially an equal distribution of combined total articles between categories for both India with USA, and India with China.
- The total articles retrieved for India with USA significantly exceeds India with China for all categories as further evidence that USA is the primary collaborator with India. This same trend would most likely exist in comparisons between India with USA, and India with all other listed countries.
- Materials Sciences; Chemistry; Biochemistry and Molecular Biology; and Physics continue as predominant categories.
- The combined total articles under Electrical and Electronic Engineering now show a significant increase compared to the total using single-term country address queries, suggesting the extent of collaboration in this category is relatively high. The combined total articles for Crystallography; Pharmacology and Pharmacy; and Plant Sciences also exhibit clearly noticeable increases in comparison.

Figure 88 (log scale) illustrates the comparative subject category total article citation trends for India, USA and China, and Figure 89 (log scale) illustrates the comparative trends for India, India with USA, and India with China, respectively.

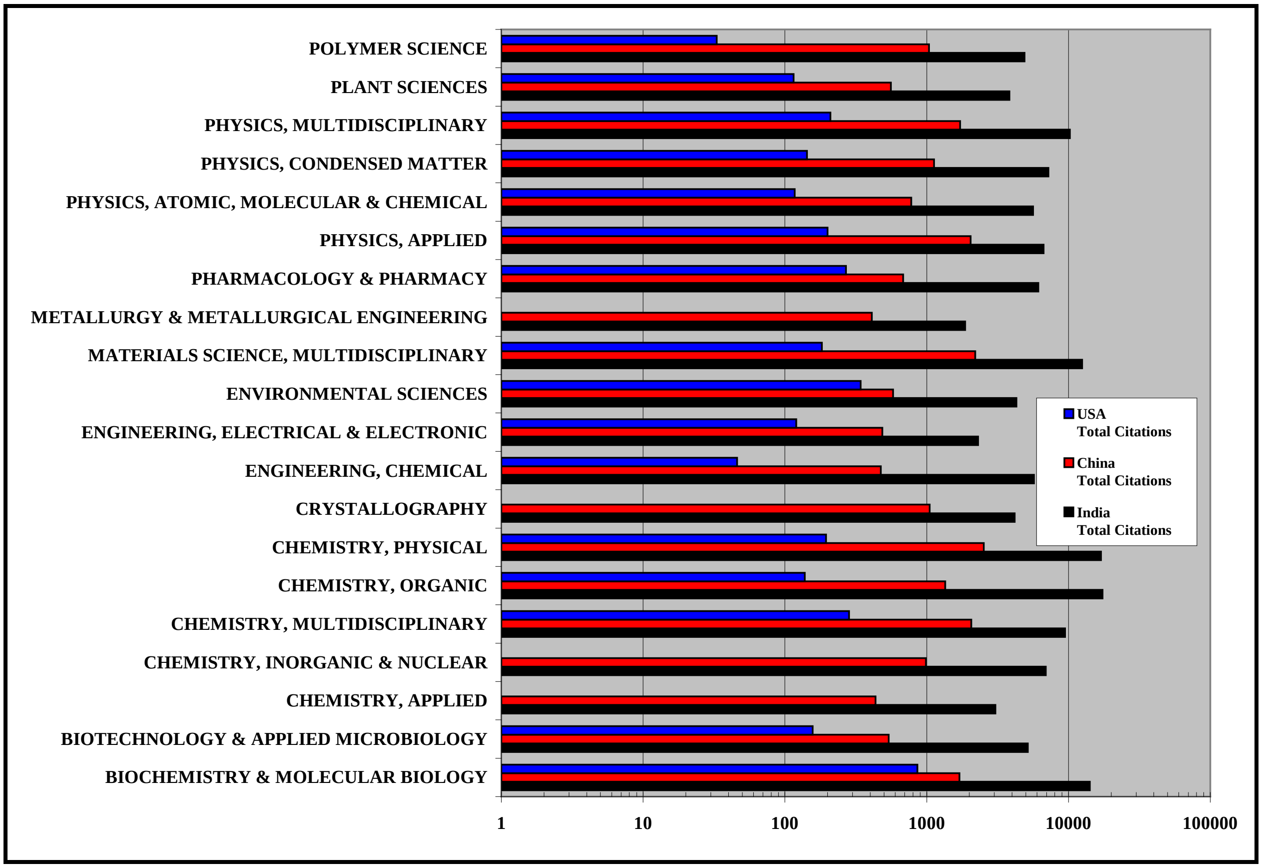

Figure 88. Comparative Category Article Citation Trends for India, USA and China

Figure 88 illustrates several important factors worth noting:

- There is a clear ranking in the distribution of total article citations between India, China and USA (in order) for all categories.
- Materials Sciences; Chemistry; Biochemistry and Molecular Biology; and Physics continue as predominant categories based on total cites.

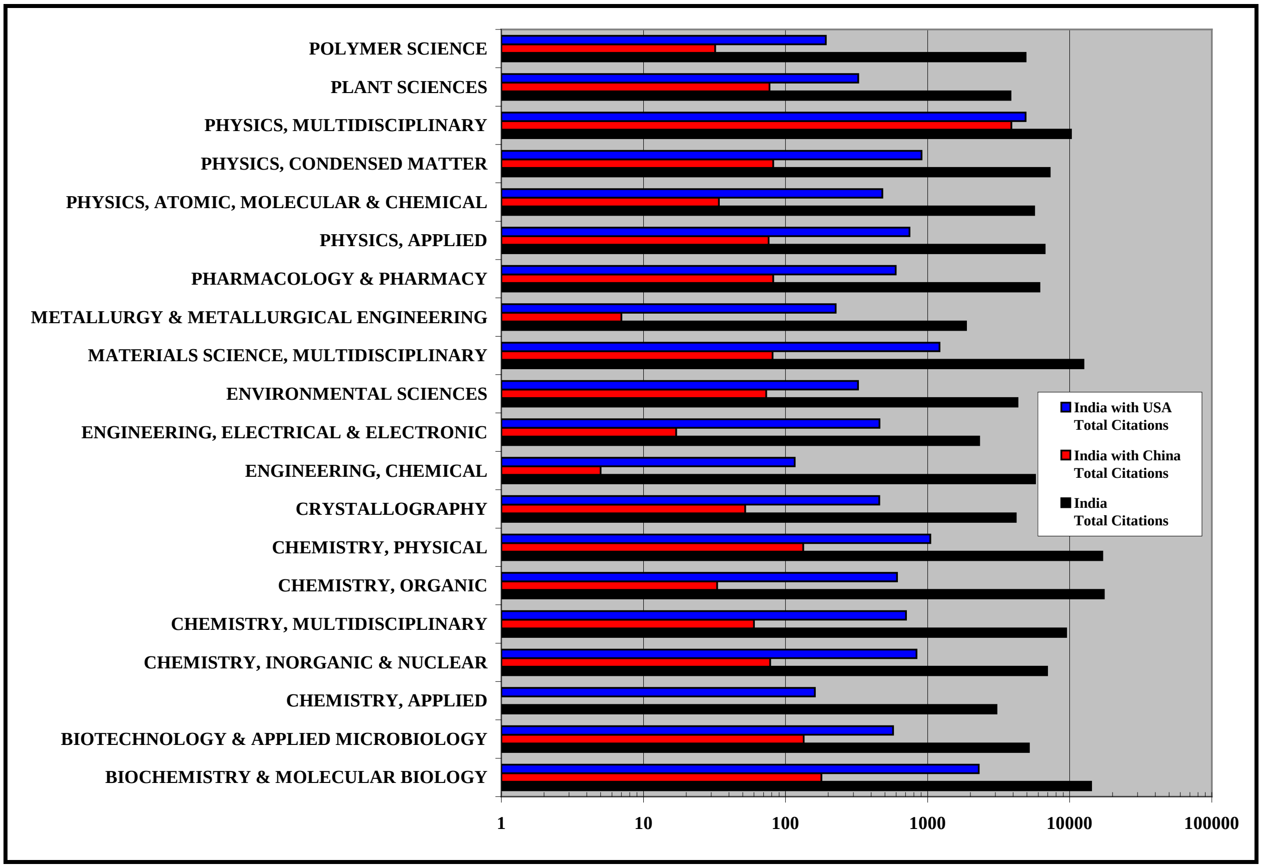

Figure 89. Comparative Category Article Citation Trends for India with USA and China

Figure 89 illustrates several important factors worth noting:

- There is a clear trend and ranking in the distribution of total article citations between India, India with USA, and India with China (in order) for all categories. This is opposite to the trend illustrated in Figure 902 for USA and China, since there is a significant decrease in total article citations in all categories for India with China addresses.
- Materials Sciences; Chemistry; Biochemistry and Molecular Biology; and Physics continue as predominant categories based on total cites.

Figure 90 (linear scale) illustrates the comparative subject category Top 10 article median citation trends for India, USA and China, and Figure 91 (log scale) illustrates the comparative trends for India, India with USA, and India with China, respectively.

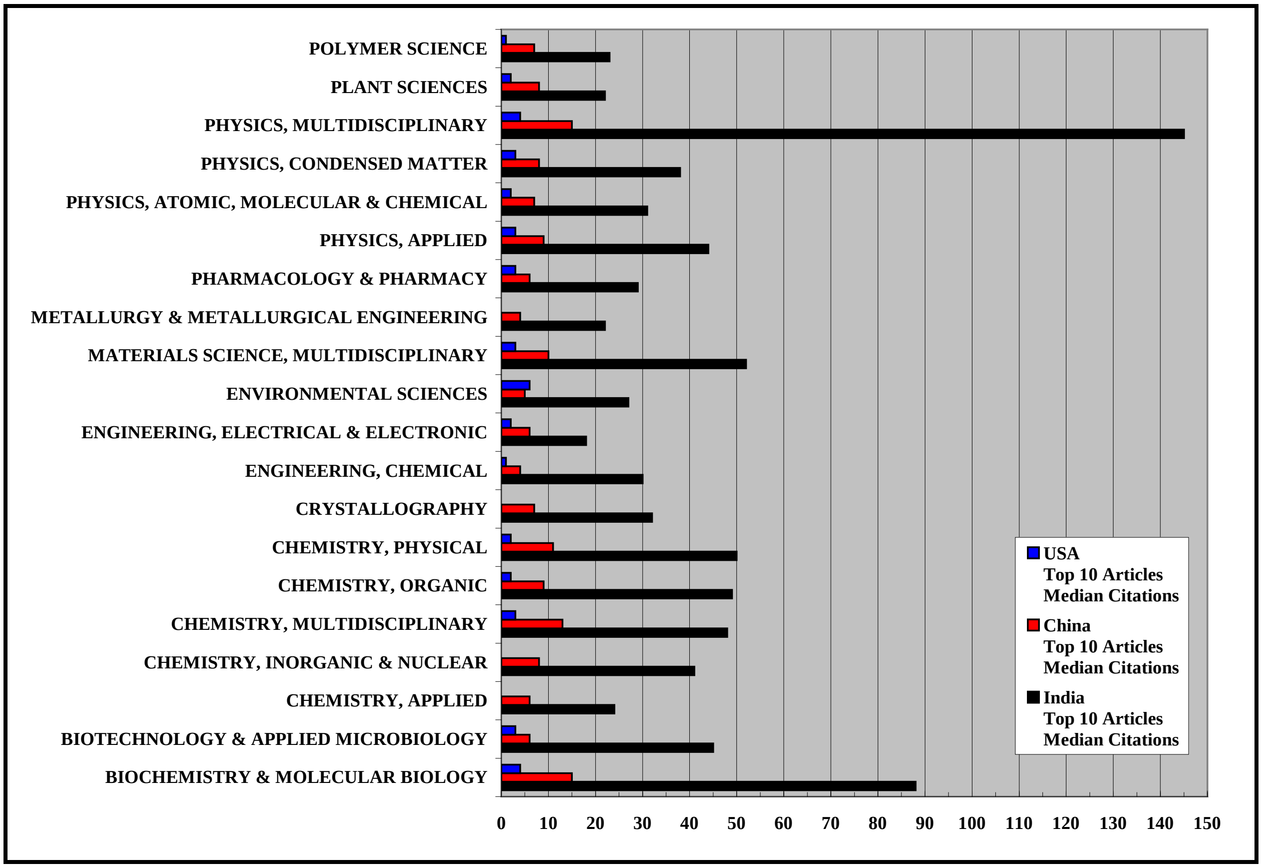

Figure 90. Comparative Category Top 10 Article Median Citation Trends for India, USA and China

Figure 90 illustrates several important factors worth noting:

- There is a clear ranking in the distribution of Top 10 article median citations between India, China and USA (in order) for all categories. There is a significant decrease in median article citations in all categories for USA addresses.
- Materials Sciences; Chemistry; Biochemistry and Molecular Biology; and Physics continue as predominant categories based on total cites.

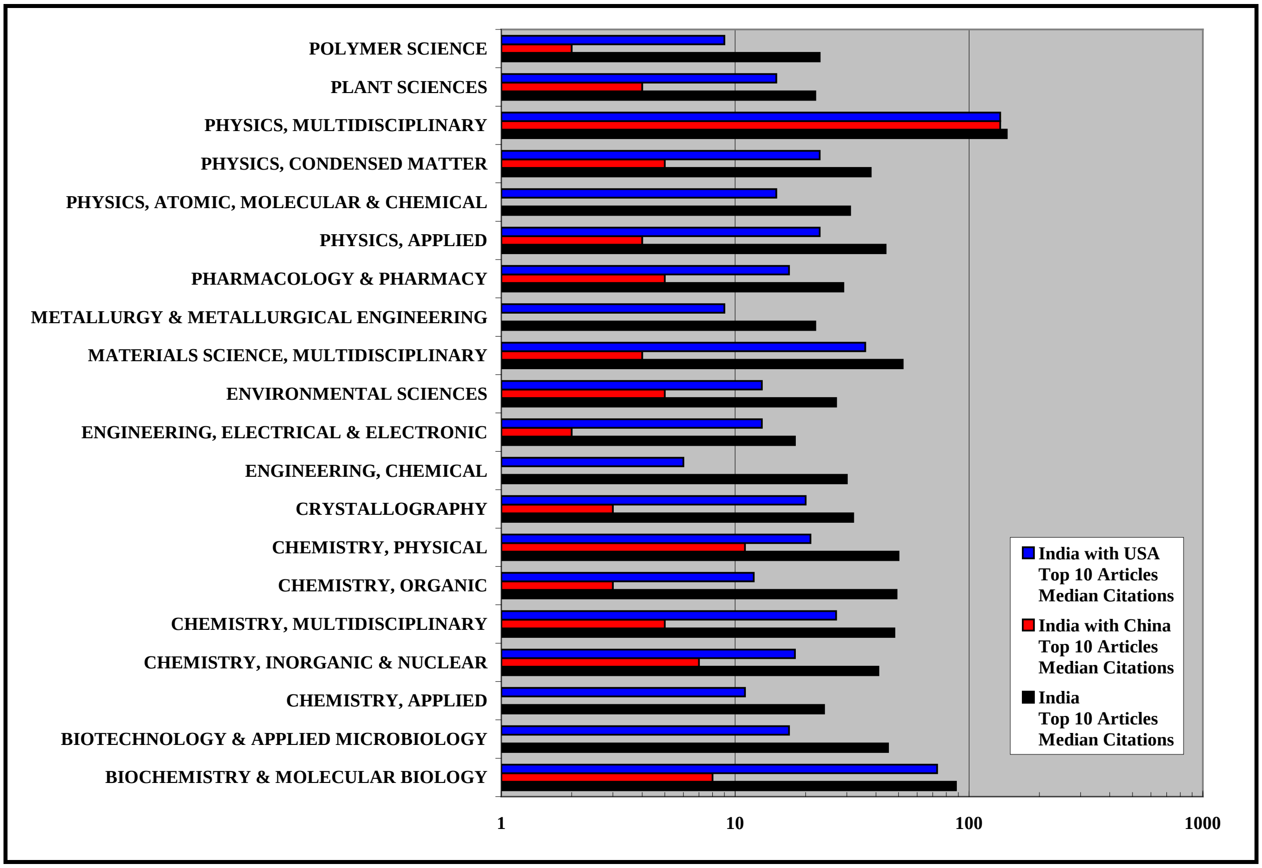

Figure 91. Comparative Category Top 10 Article Median Citation Trends for India with USA and, India with China

Figure 91 illustrates several important factors worth noting:

- Again, there is a clear trend and ranking in the distribution of Top 10 article median citations between India, India with USA, and India with China (in order) for all categories. This is opposite to the trend illustrated in Figure 90 for USA and China, since there is a significant decrease in median article citations in all categories for India with China addresses.

Figure 92 (log scale) illustrates the comparative subject category Top 10 article (from Top 10 Journals) median citation trends for India, USA and China, and Figure 93 (log scale) illustrates the comparative trends for India, India with USA, and India with China, respectively.

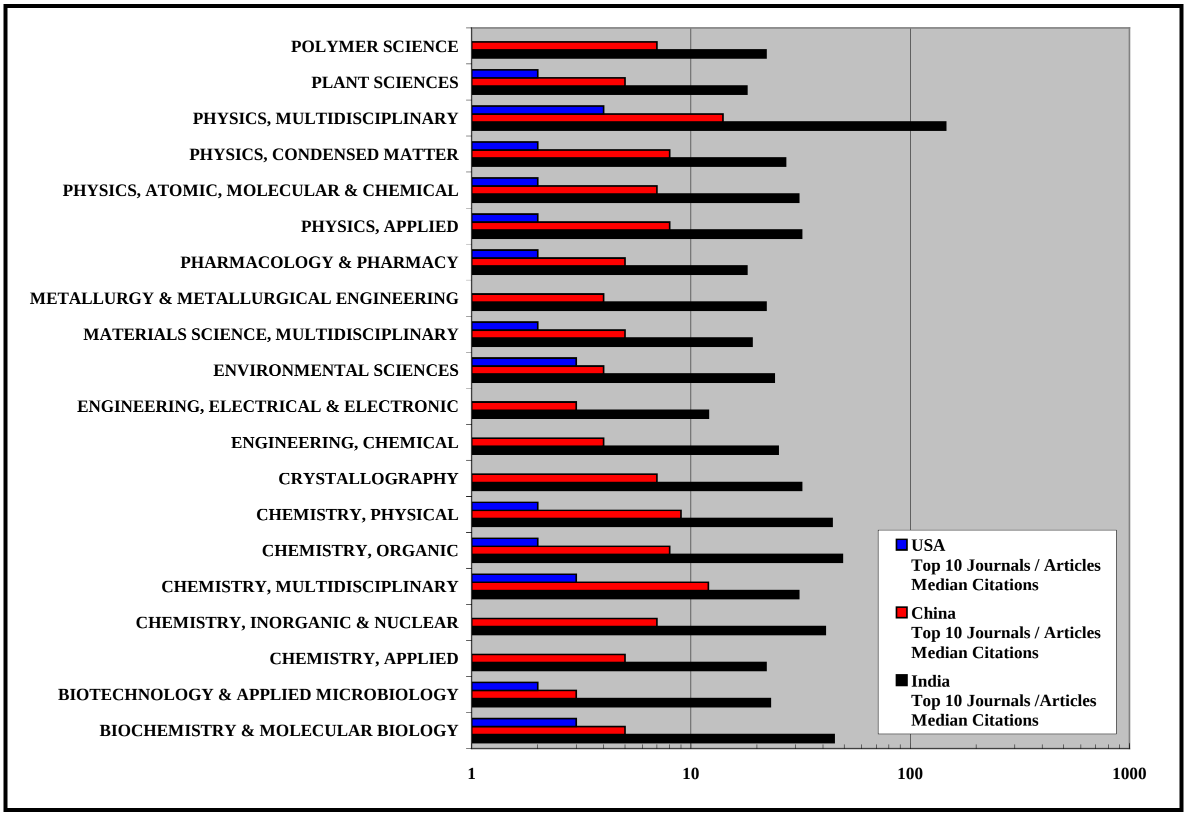

Figure 92. Comparative Category Top 10 Article - Journal Median Citation Trends for India, USA and China

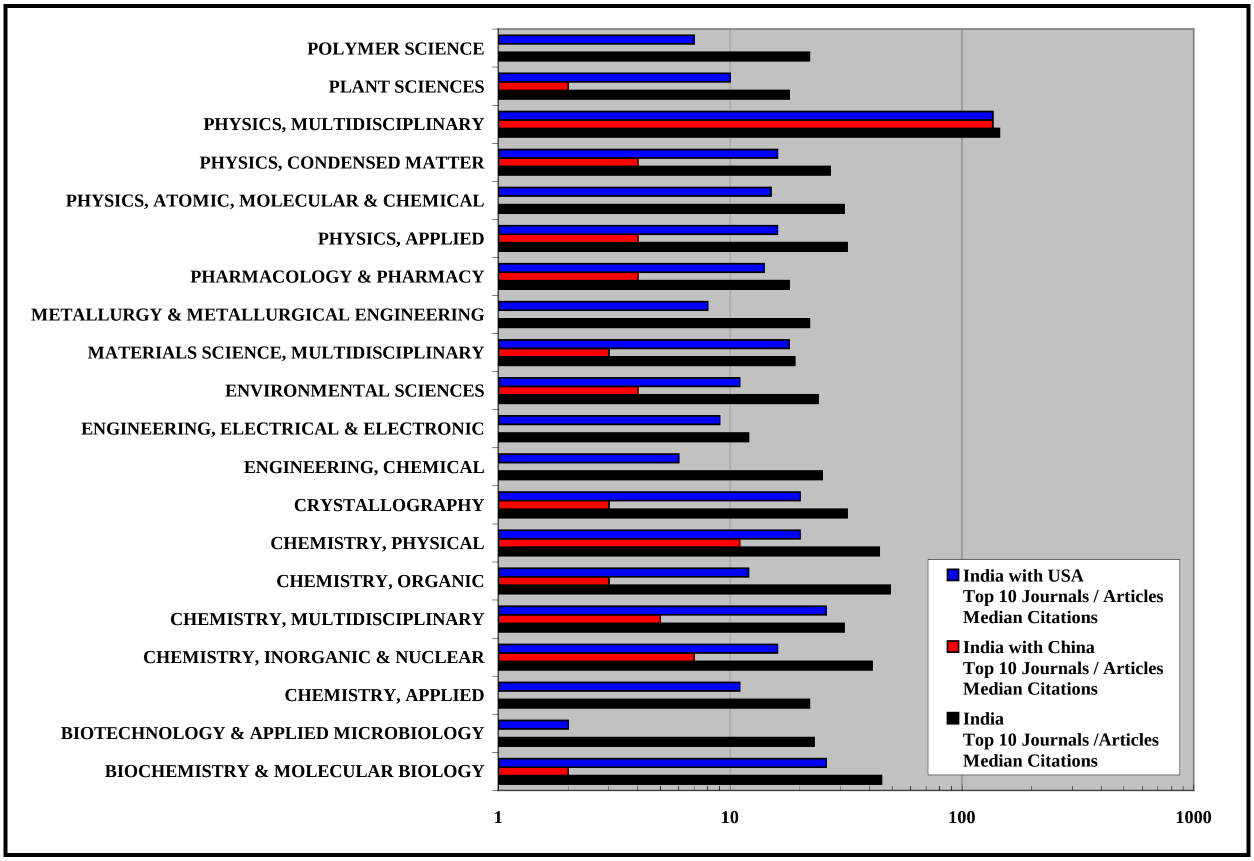

Figure 93. Comparative Category Top 10 Article Median Citation Trends for India with USA and China

Figures 92 and 93 illustrate several important factors worth noting:

- Again, there is a clear trend and ranking in the distribution of the median citation of the Top 10 articles from the Top 10 Journals between India, China, USA (in order), and India with USA, and India with China (in reverse order) for all categories. This is consistent with the trends illustrated above for total citations (all articles), and median citations (Top 10 articles from all Journals).

Figure 94 (linear scale) illustrates the comparative subject category average citation trends (all articles) for India, USA and China, and Figure 95 (linear scale) illustrates the comparative trends for India, India with USA, and India with China, respectively.

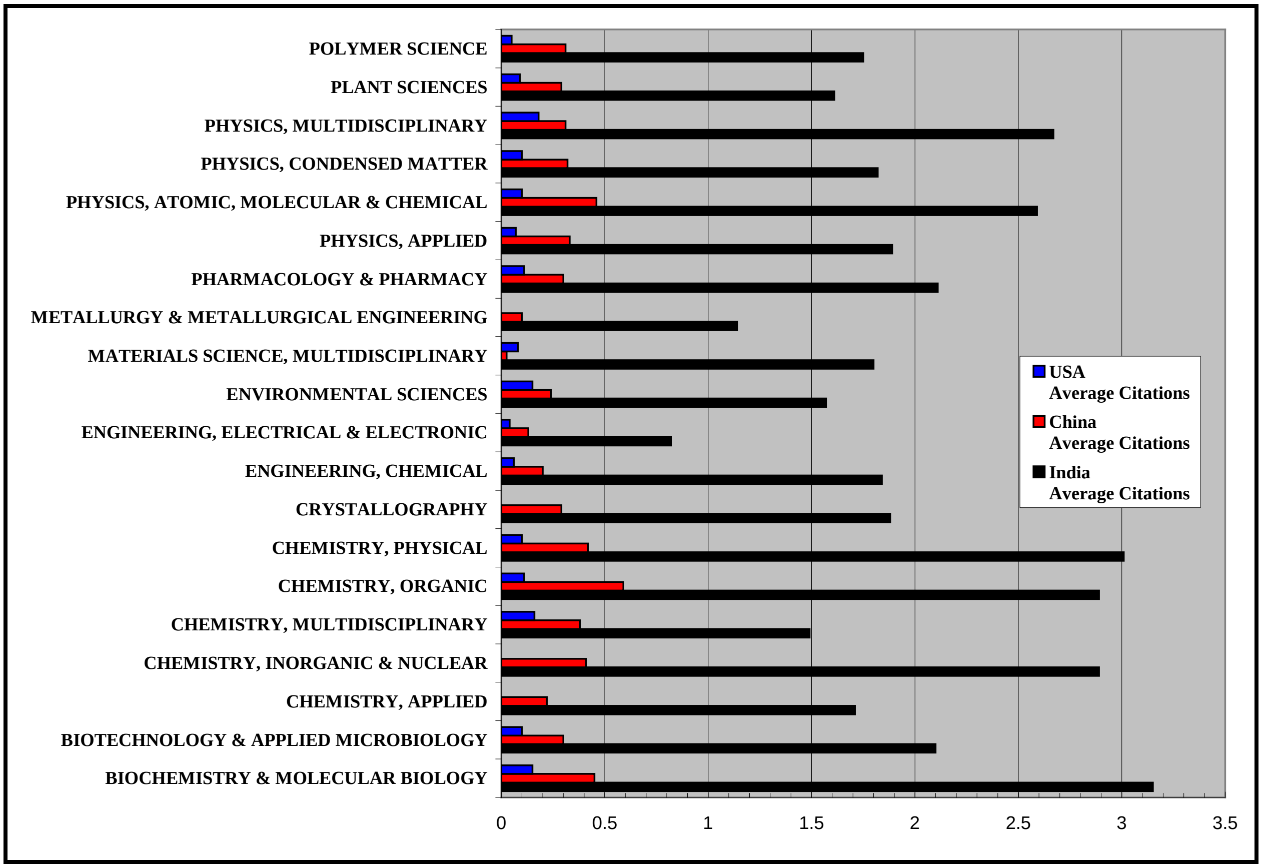

Figure 94. Comparative Category Average Citation Trends for India, USA and China

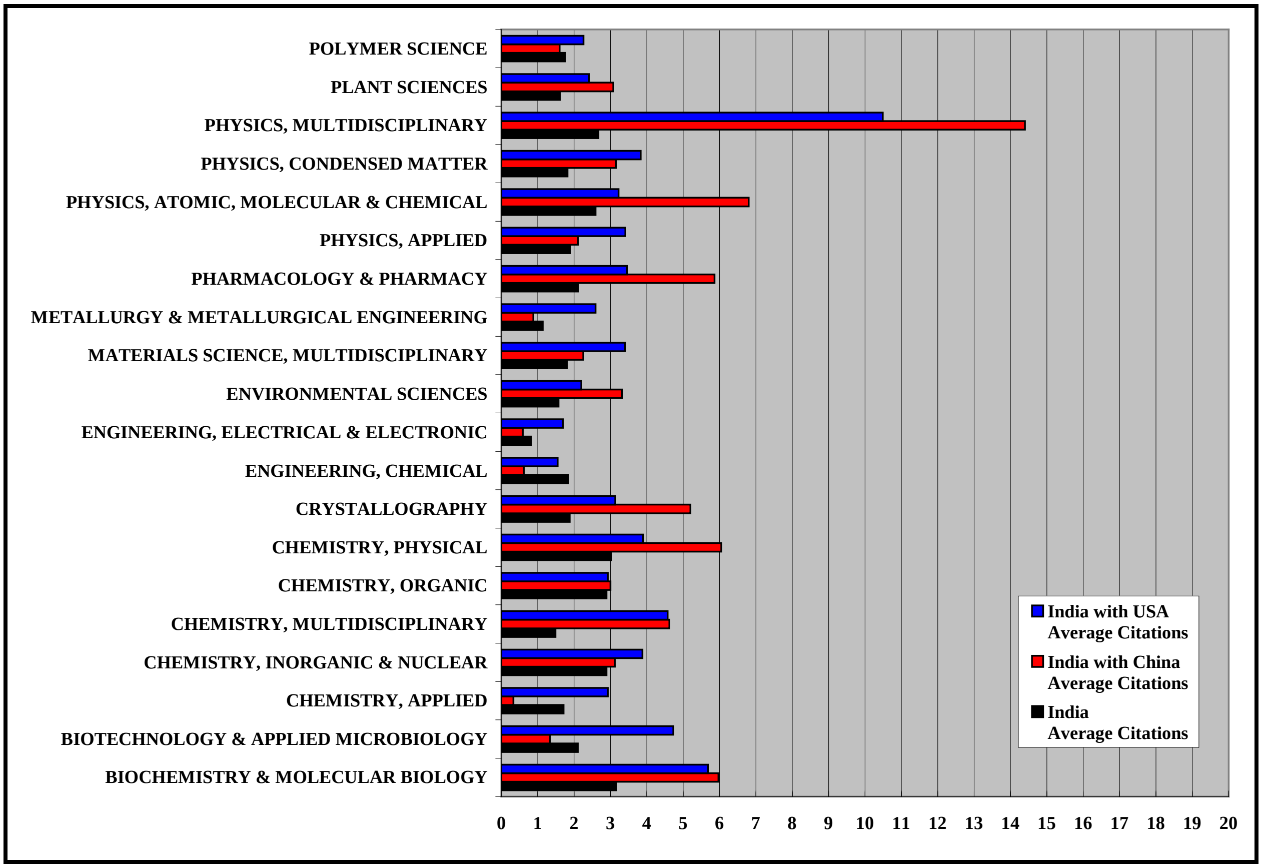

Figure 95. Comparative Category Average Citation Trends for India with USA and China

Figures 94 and 95 illustrate several important factors worth noting:

- The trend and ranking in the distribution of the average citation (all articles) is similar to total (all articles) and median citation (Top 10 articles/journals) trends between India, China, USA (in order).
- However, the trends and rankings in the distribution of the average citation for India, India with USA, and India with China now have dramatic relative shifts and are completely different from all category trends illustrated above. The average article citations for both India with China, and India with USA addresses, now exceed those of India only.
- There are also no clearly defined relative trends as the average citations fluctuate throughout all categories. The fluctuations are probably not random however, and are likely based on the nature of published research that is specific to each subject category. The nature of publication in this case concerns cumulative article citation rates and journal impact factors that in general cannot be compared across technical disciplines such as applied physics and plant sciences.

To provide a different perspective, Figure 96 (linear scale) illustrates the comparative subject category average citation trends (all articles) for India, China, and India with China for direct comparison. Figure 97 (linear scale) illustrates the comparative trends for India, USA, and India with USA, respectively.

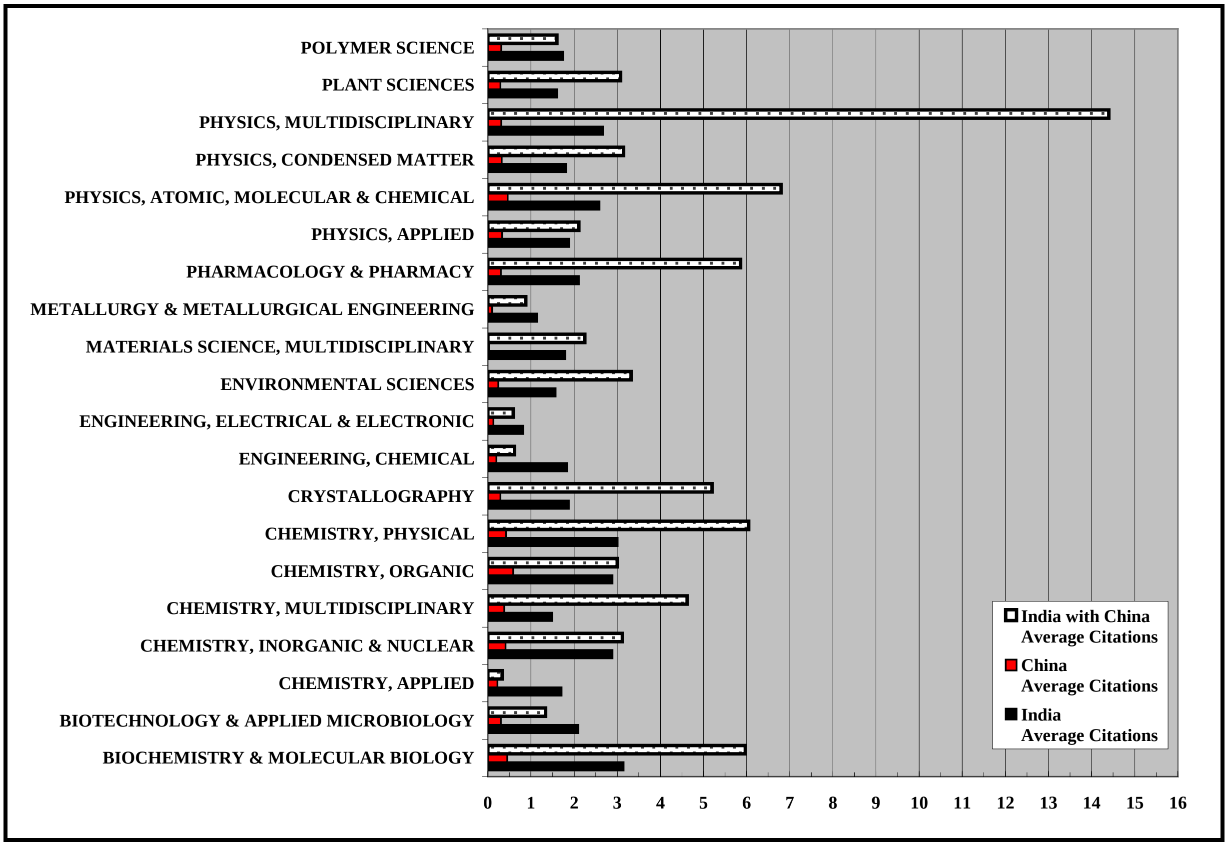

Figure 96. Comparative Category Average Citation Trends
for India, China and India with China

Figure 96 and 97 illustrate several important factors worth noting:

- The trend and ranking in the distribution of the average citation (all articles) is clearly defined. The dramatic relative shift in average citation for India with China is evident when compared to both India and China only. The overall effects of collaboration, based on articles containing both India and China addresses, is further amplified for specific subject categories such as Physics; Chemistry; Biochemistry and Molecular Biology; and Pharmacology and Pharmacy.
- The dramatic relative shift in average citation for India with USA is also evident when compared to both India and USA only.
- The average citations for USA were not available in several categories including Applied Chemistry; Inorganic and Nuclear Chemistry; Crystallography; and Metallurgy and Metallurgical Engineering, as these were not listed in the SCI/SSCI Analyst Top 100 categories. The average citations of articles contained in these categories is insignificant.

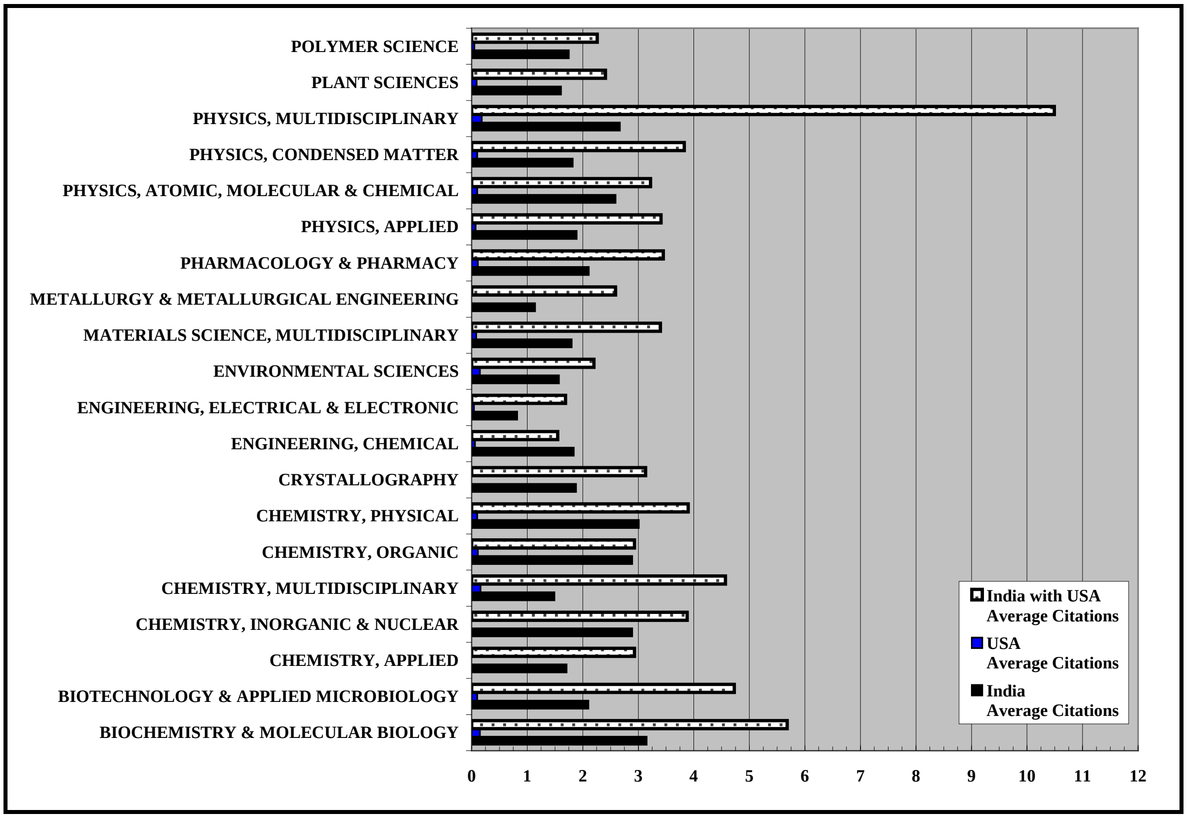

Figure 97. Comparative Category Average Citation Trends for India, USA and India with USA

4.4.3 Collaboration Analysis Summary

The extended India research collaboration analysis for subject categories provides a final perspective of the nature of India collaborative research with the USA and Peoples Republic of China. The analysis used several Country address queries to determine the impact (effects) of collaboration on the overall regarded utility of the research based on article citations and associated Journal impact factors. Specifically, the analysis focused on determining if these effects are evident across a generalized taxonomy of India research, based on assigned Top 20 subject categories, as opposed to the single-technology level.

The analysis initially used the INDIA address (ONLY) query to identify the prominent Subject Categories assigned by the SCI/SSCI database for the period (2000-2007). For comparison, the analysis then used USA (ONLY) and China (ONLY) address queries to retrieve all articles in order to identify the Top 20 Subject Categories that coincide for India, USA and China. Finally, the SCI/SSCI Analyst Tool was used to exclude other Country addresses to retrieve all articles with both (India with USA) and (India with China) addresses for the same identical Top 20 Subject Categories. Output and citation data for these five sets of articles were then presented to establish comparative output publication trends and to illustrate the effects of collaboration on citations across the generalized taxonomy of India research encompassed by the Top 20 subject categories.

The total number of articles contained within the Top 20 Subject Categories represented a significant percentage (56%) of the total number of articles retrieved. India and China have a similar distribution of total articles between categories with Materials Sciences; Chemistry; Biochemistry and Molecular Biology; and Applied Physics as the predominant categories. USA's only dominant category is Biochemistry and Molecular Biology.

There is a clear ranking in the distribution of total citations for all articles; median citation for Top 10 articles; and median citation for Top 10 articles from the Top 10 Journals; between India, China and USA (in order) for all categories. However, the trends and rankings in the distribution of the average citation for India, India with USA, and India with China have dramatic relative shifts and are completely different. The average article citations for both India with China, and India with USA addresses, exceed those of India only. There are also no clearly defined relative trends as the average citations fluctuate throughout all categories. The fluctuations are probably not random however, and are likely based on the nature of published research that is specific to each subject category. The nature of publication in this case concerns cumulative article citation rates and journal impact factors that in general cannot be compared across technical disciplines such as applied physics and plant sciences.

Finally, as stated in Section 3 (Bibliometrics Approach and Results), article publication and citation bibliometrics should only be viewed as measures of output and productivity. These metrics are not direct measures of research quality, although there is some threshold quality level inferred, since (in the present study) these papers are published in the (typically) high caliber journals accessed by the SCI/ SSCI, EC and INSPEC databases. Similarly, the determination of Journal impact factors are based on numerous factors unrelated to the scientific quality of contained articles. As previously stated, Journal impact factors are published annually in SCI/SSCI Journal Citation Reports (JCR) and are widely regarded as a quality ranking for journals. Impact factors are also used extensively by prominent Journals in their advertising campaigns.

However, impact factors are not true or dependable measures of journal quality. Article citation rates determine the journal impact factor and the number of citations to articles in a specific journal do not directly measure the true quality of the journal or the scientific/technical merit of the contained articles. Impact factors also depend on the specific field of research as high impact factors are more likely in journals covering large areas of basic research that utilize many references per article. In addition, different fields of research have very particular article publication and citation practices that affect both the total number of cites, and overall citation rate based on how rapidly most articles in the field reach their highest level of citation. For example, journals with a short publication lag may allow many short-term self-citations with resultant inflated impact factors. In addition, for emerging rapidly expanding research fields, the number of publications generating citations is large relative to the amount of citable material, leading to inflated articles citation rates and journal impact factors. It is anticipated that impact factors exhibit similar dependencies with regard to the Top 20 subject categories analyzed. Thus, although the utility of impact factors is appropriate for some fields of research such as Applied Physics and Biochemistry and Molecular Biology, they may not appropriate for use in subject categories that exhibit slower publication patterns, such as plant and environmental sciences. Therefore, the absolute value of an impact factor is meaningless, and the comparison of impact factors across the different fields of research or subject categories is invalid. The utility of Journal impact factors in bibliometric analyses must also account for the difference in article citation rates. JCR statistics indicate articles in the most cited half of articles in a specific Journal are cited 10 times as often as the least cited half).

Conclusively, the only viable methodology that can be used to assess the quality of research is peer article review. Unfortunately, current peer review practice usually results in article reviews being performed by committees with general competence, as opposed to subject experts, that tend to utilize secondary assessment criteria including raw publication counts, journal prestige, the reputation of authors and institutions, and estimated importance and relevance of the research field.

5 Research Expenditure / Output Comparison

The final analysis of the India S&T literature assessment examines the relation between the budget allocations for each India S&T Department/Ministry (2005-2006) of Table 3 (Ref: 10) and the total combined categorized output from all databases. Specifically, the total categorized output comprises all combined research articles from each set of SCI/SSCI, EC and INSPEC Level 4 clusters (research focus areas) identified from taxonomy analyses. The total number of research articles listed by the CLUTO clustering algorithm for each database root cluster (or the sum of Level 4 clusters) was as follows:

- SCI/SSCI = 46,819 total articles
- EC = 23,584 total articles
- INSPEC = 18,851 total articles
- Combined = 89, 254 total articles

The aggregate tertiary (red) category headings for the taxonomy depicted above for SCI/SSCI (Table 22), EC (Table 24) and INSPEC (Table 25) were used to produce research output categories for classification under the eight S&T Department/Ministry research expenditure areas (excluding Defense Department and Non-conventional energy). Table 44 provided below lists the combined (all databases) category classification for each of the eight expenditure areas. Table 44 also provides a complete listing of relative budget allocations, total number of research articles, and the ratio of budget allocation percentage assigned to the eight expenditure areas to the percentage of research articles assigned to these same areas.

TABLE 44. INDIA S&T DEPARTMENT/MINISTRY BUDGET AND TOTAL PUBLICATION PERCENTAGES

S&T Department/Ministry	Revised Budget (crore rupees)	% Budget Allocation	Total Articles	% Combined Articles	Ratio (% Budget) / (% Articles)
Space astronomy and astrophysics	3148	17.52%	5546	6.21%	2.82
Science & Technology thin film research physical chemistry inorganic chemistry chemical synthesis colloid and interface science organic compounds chemical synthesis/doping polycrystalline and nanostructured materials chemical engineering mathematical models and computer simulation telecommunications information technology solid-state / semi-conductor materials and devices microwave and optical technology physics of fluids structural design and analysis crystal growth	1636	9.11%	46301	51.88%	0.18
Atomic Energy nuclear and particle physics plasma physics	2895	16.12%	5546	6.21%	2.59
Ocean Development marine sciences	377	2.10%	1056	1.18%	1.77
Medical research (Health) clinical medicine neurology and neuroscience human patient diseases	1361	7.58%	2825	3.17%	2.39
Scientific & Industrial Research mathematical models and computer simulation electric power systems and components electric power distribution and control pattern recognition and machine intelligence production and operational research information technology	1557	8.67%	9079	10.17%	0.85
Biotechnology microbiology and biotechnology	459	2.56%	4551	5.10%	0.50
Agricultural research environmental sciences molecular and cellular biochemistry microbiology and biotechnology agronomy / plant and food sciences	6531	36.36%	14350	16.08%	2.26
Totals	17964	100.00%	89254	100%	1
1 Indian Rupee (INR) = 0.02 US Dollars (USD) 1 crore Rupee = 10 million Rupees					

Figure 98 illustrates on a logarithmic scale the total (2005-2006) budget allocations and total research article publications assigned to each expenditure area.

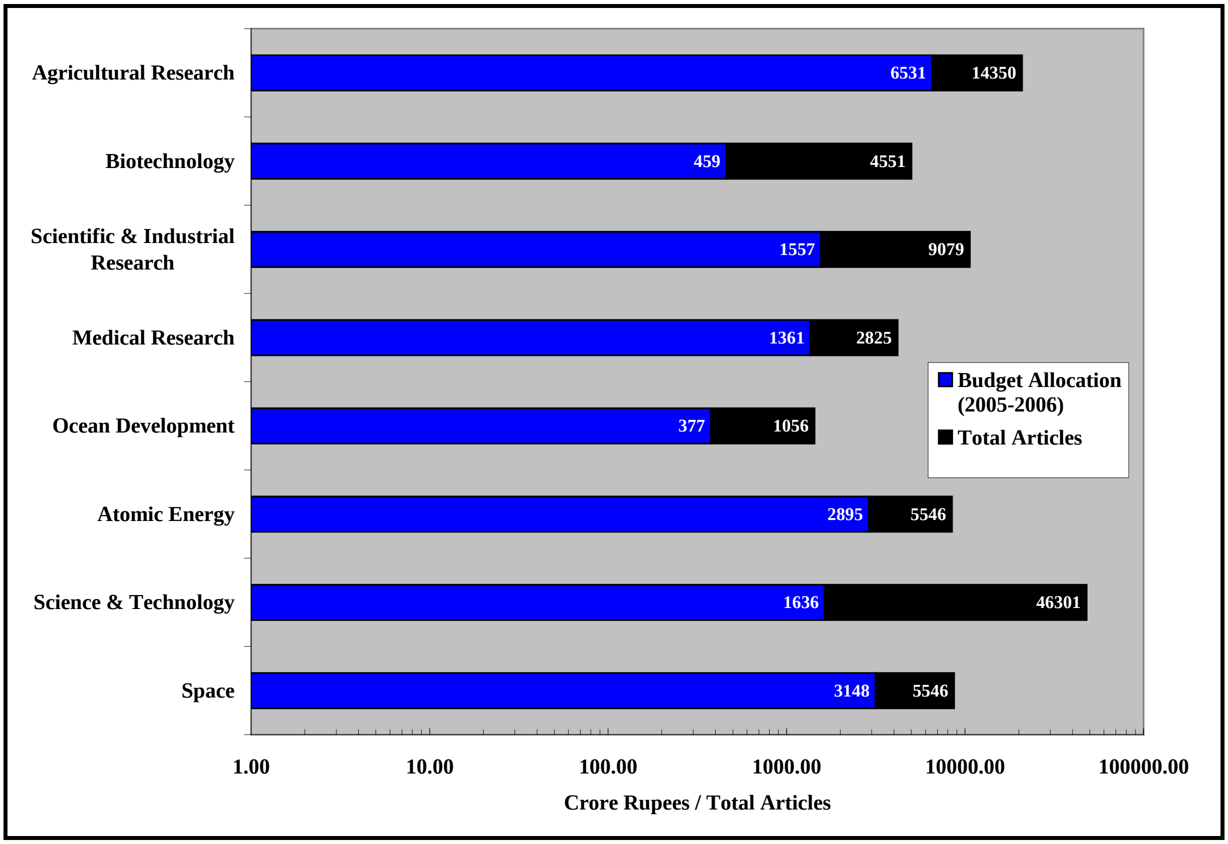

Figure 98. India S&T Budget Allocation and Total Publications

Figure 99 shows the budget allocation and total publication percentages (2005-2006).

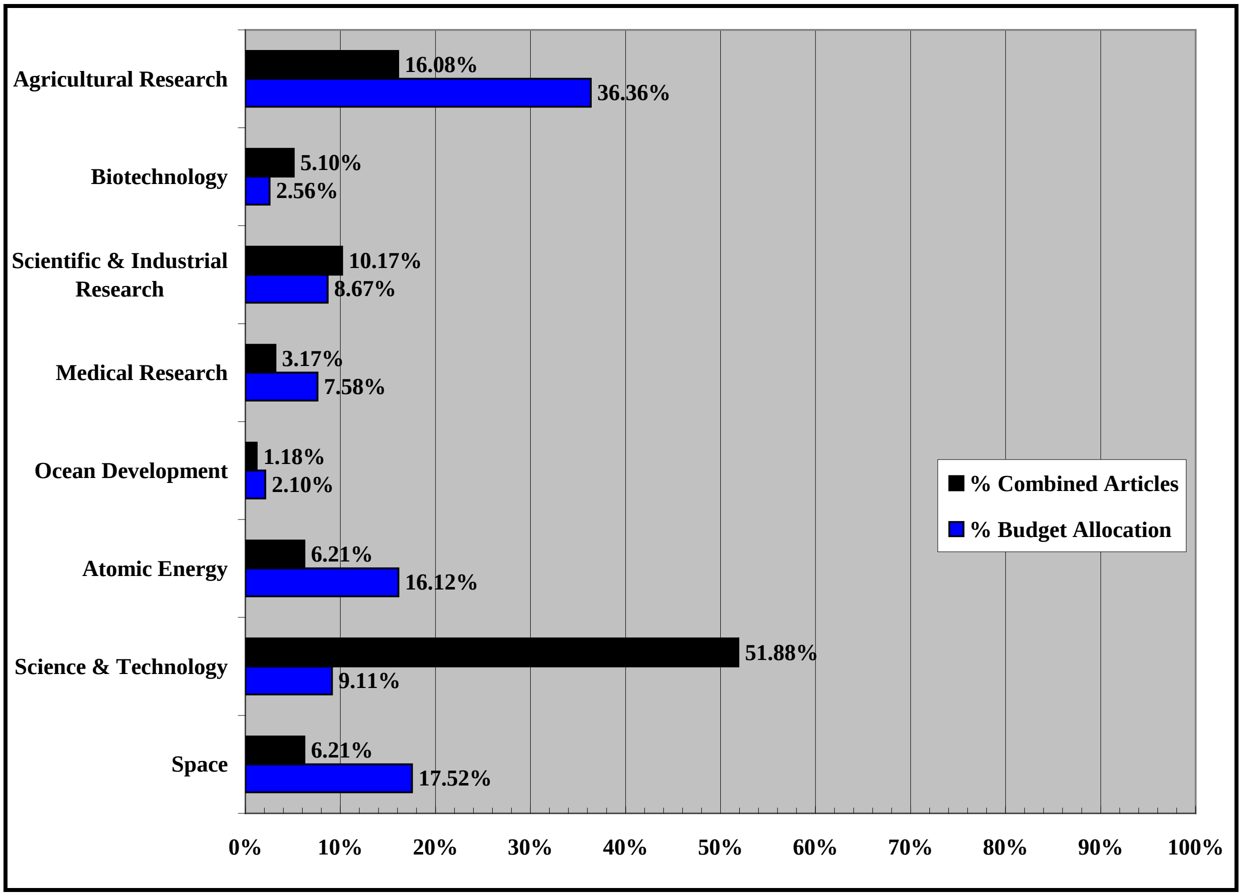

Figure 99. India S&T Budget Allocation and Total Publication Percentages

Figure 100 shows the ratio of budget allocation percentage to publication percentage relative to the combined total articles (2005-2006).

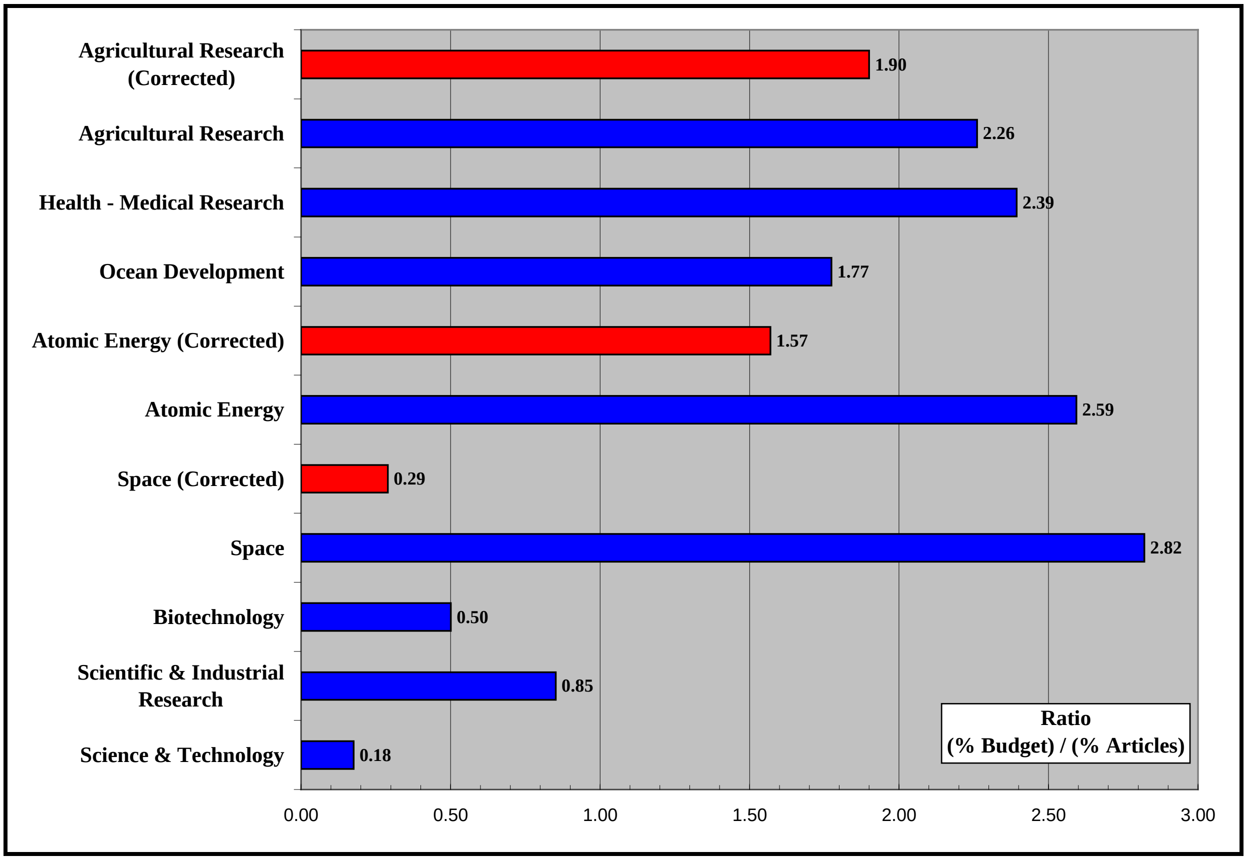

Figure 100. India S&T Budget Allocation / Total Publication Percentage Ratio

The subjective nature of this analysis is noted; and while different assignments of the sixteen output categories for each database to the eight expenditure areas are certainly possible, nevertheless, the relative imbalances depicted in Figure 100 are probably realistic. It is also noted that the budget allocation percentages for certain S&T Departments/Ministries could be adjusted to account for expenditures not related to, or resulting in the output of published research literature. For example, the majority of the total budget (3148 INR) for the Department of Space (DoS) is allocated to Launch Vehicle Technology (1161/3148), Satellite Technology (793/3148) and Launch Support, Tracking Network and Range Facilities (195/3148) accounting for (2149/3148) of the total allocated budget. The total outlay for Space Sciences is only (243/3148). If only Space Sciences are considered, the ratio depicted in Figure 100 decreases from 2.82 to 0.29 approximating the ratio for the Department of S&T (0.18). Similarly for the Ministry of Agriculture under the Department of Agriculture and Cooperation the actual allocations (4589/6531) could be slightly reduced to approximately (3587/6531) by accounting only for crop husbandry and soil/water conservation research. The allocation for the Department of Agricultural Research and Education (1942/6531) is unchanged (Refer to Table 3). In this case, the ratio for Agricultural Research depicted in Figure 100 decreases from 2.26 to 1.90. Additional in-depth analysis would identify even further warranted reductions. Lastly, for the Department of Atomic Energy (DAE), the actual allocations (2895 INR) could be reduced to approximately (1750 INR) by eliminating allocations associated with nuclear fuel and heavy water production projects, and investments in public enterprises. In this case, the ratio for

Atomic Energy Research depicted in Figure 100 decreases from 2.59 to 1.57. Again, additional in-depth analysis would identify even further warranted reductions.

Since the primary objective and scope of this study was to examine the structure of India's research at the higher levels, accordingly, the sixteen categories for the SCI/SSCI, EC and INSPEC (2005-2006) databases are at a relatively coarse level of resolution. In particular, much more accurate results relating research outputs to research allocations would be possible with much more well-defined categories. An assessment oriented toward more specific technology analyses would require narrower more well-defined clusters, translating into using a larger number of clusters. The present technique is fully translatable into analyzing hundreds or thousands of clusters. The final note is that this analysis was based on budget allocation data since complete actual expenditure data for each S&T Department/Ministry is currently unavailable.

6 Major Findings and Conclusions

This section provides a listing of major findings and related conclusions based on the bibliometrics and document clustering analysis results discussed above. A Summary Report of all analysis results is provided in a separate publication (Ref: 17) that accompanies this document.

6.1 Bibliometrics

All research articles in the SCI/ SSCI, EC and INSPEC databases having at least one author with an India address were retrieved for the period (1980-2005). The select literature for this period was retrieved by both relative intervals (bands) and individual years. The relative intervals were used to allow gross comparison of additional bibliometric trend data for the period (1980–2005) associated with subject categories, author affiliations and country addresses, as it was not feasible to process this amount of data for each individual year over the entire period (1980-2005). All research articles in the these databases having at least one author with an India address were also retrieved for the time period (2005-2006) to update the bibliometrics provided in the preceding study.

6.1.1 Overall India Bibliometrics

- The total output production (total of number of published articles at least one author with an India address) over the time period (1980-2005) by individual years were distributed as follows:

SCI/SSCI Total Articles	= 367,069
EC Total Articles	= 134,729
INSPEC Total Articles	= 150,470
Total Articles	= 652,268

The SCI/SSCI, EC and INSPEC total article publication trends for the period (1980-2005) are reproduced below in Figure 5. The trends clearly indicate a consistent increase in published articles for each database, except for the EC total articles associated with the interval (1983-1992).

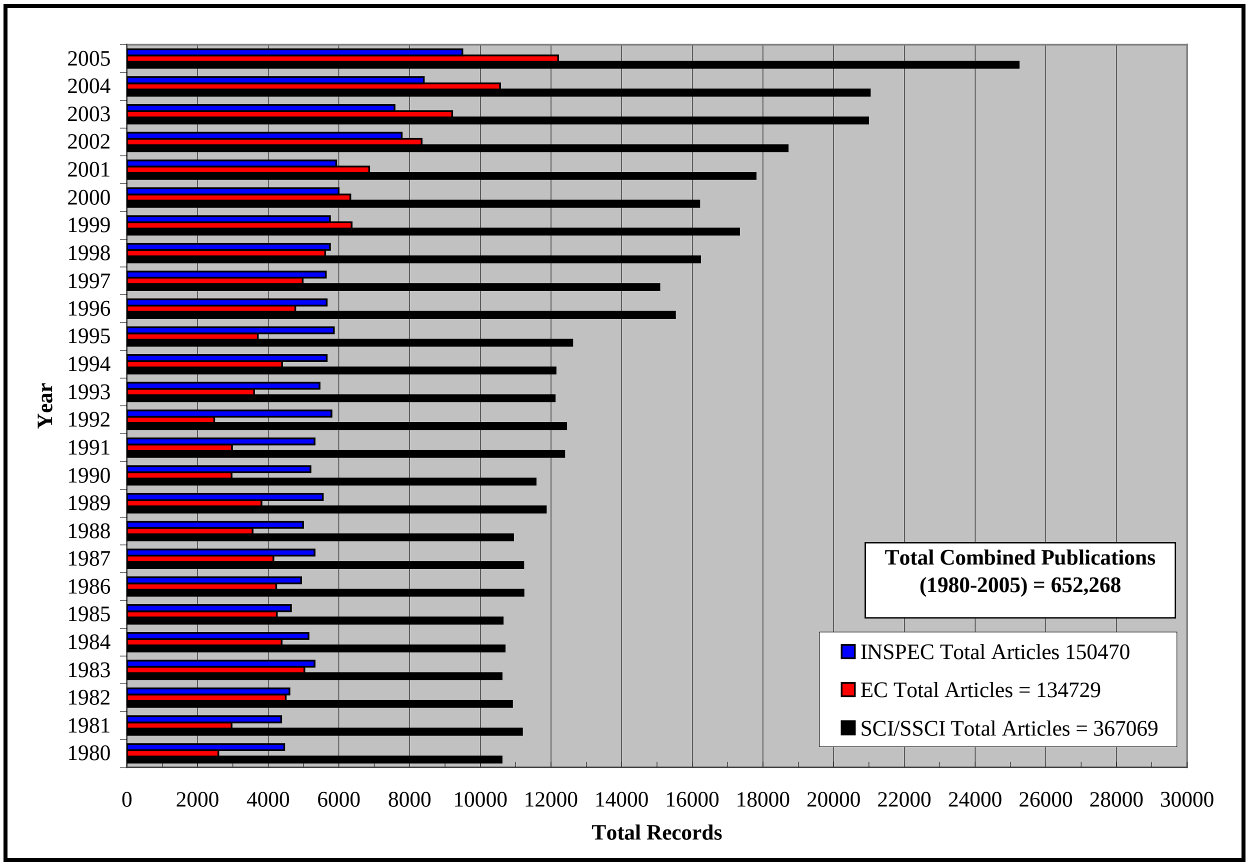

Figure 5. SCI, EC and INSPEC (1980-2005) Total Publications by Years

In addition to the (1980-2005) trends, all research articles in the SCI/SSCI, EC and INSPEC databases having at least one author with an India address were also retrieved for the period (2005-2006) to provide publication trends for comparison to the preceding study based on SCI/SSCI (2005) data. The publication trends for the period (2005-2006) are reproduced below in Figure 6, and the total combined articles retrieved from all databases were distributed as follows:

SCI/SSCI Total Articles	= 52,047
EC Total Articles	= 4,430
INSPEC Total Articles	= 5,506
Total Articles	= 61,983

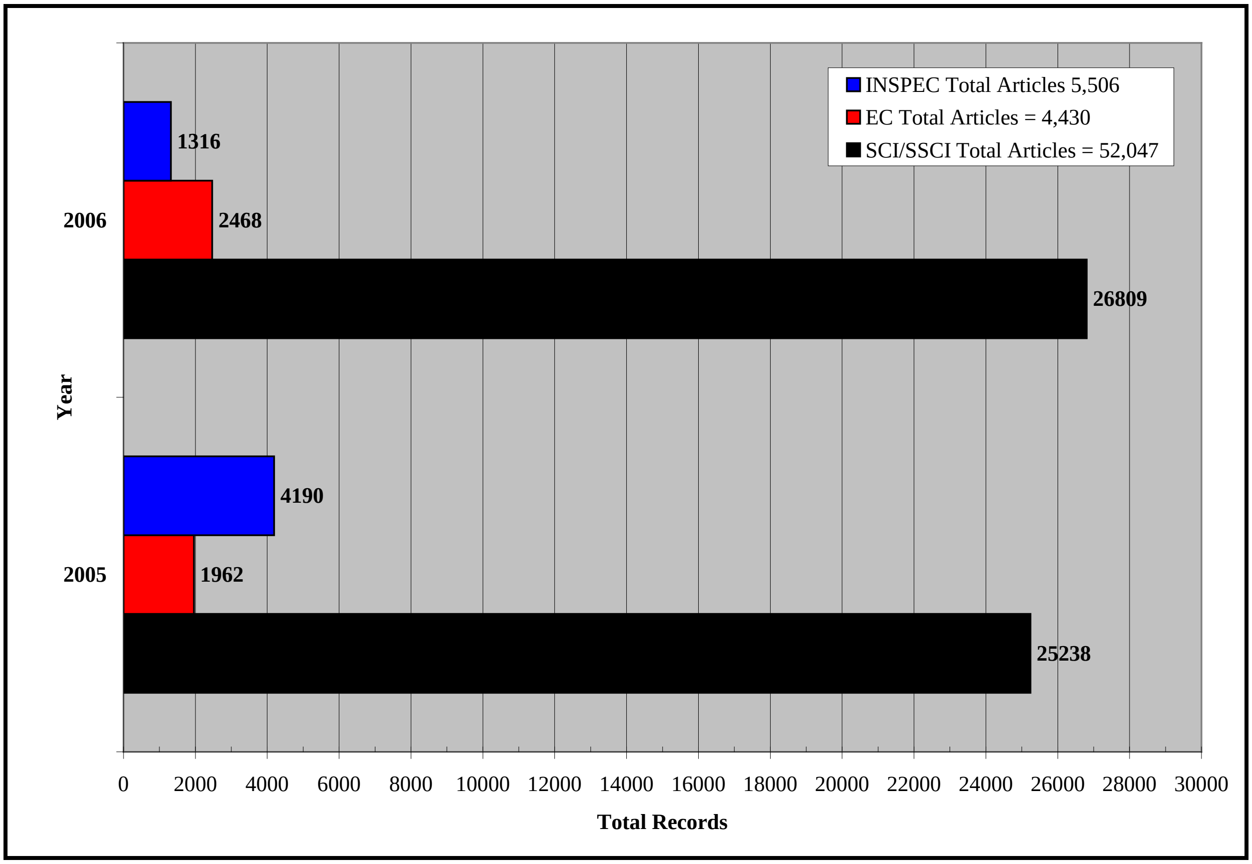

Figure 6. SCI, EC and INSPEC (2005-2006) Total Publications

Thus, the total output production (total of number of published articles) over the entire combined period (1980-2006) was distributed as follows.

SCI/SSCI Total Articles	= 419,116
EC Total Articles	= 139,159
INSPEC Total Articles	= 155,976
Total Articles	= 714,251

- A comparative analysis was performed for the Peoples Republic of China. All research articles in the SCI/ SSCI, EC and INSPEC databases having at least one author with a China address were retrieved for every year from 1980-2006.

  * The differences between China and India are dramatic! In the SCI/SSCI database from 1980-2006, China's research article output increased by two orders of magnitude (731 articles - 82,205 articles), while India's output increased by 2.5 (10,606 articles - 26,814 articles), a factor of forty difference! Similarly, in both the EC and INSPEC databases (combined), China's research article output increase is even more dramatic (1376 articles - 189,997 articles), while India's output increased by 3.5 (7,038 articles - 24,245 articles), again a factor of forty difference!

- For the SCI/SSCI database, the publication trends for subject categories indicates the percentage of records published within the Top 10 disciplines during (2005-2006) ranged from approximately 2.8 % (Pharmacology) – 6.8 % (Materials Sciences). Food Science and Technology, Agricultural Research, and Animal Sciences are newly listed categories emerging for this period.

- For the SCI/SSCI database, the publication trends for Affiliations (institutions) indicates the percentage of records published within the Top 10 Affiliations during (2005-2006) ranged from approximately 1.5 % (Banaras Hindu University) – 12.4 % (Indian Institute of Technology), relative to the total number of extracted records (52,047).

- For the EC database, the percentage of records published within the Top 10 Affiliations during (2005-2006) ranged from approximately 0.25 % (National Institute of Oceanography) – 6.6 % (Indian Institute of Technology), relative to the total number of extracted records (24,475).

- For the INSPEC database, the percentage of records published within the Top 10 Affiliations during (2005-2006) ranged from approximately 0.1 % (Defense Metallurgical Research Lab) – 5.5 % (Indian Institute of Technology), relative to the total number of extracted records (18,988).

- For the SCI/SSCI database, the publication trends for countries that collaborate with India on basic research indicate the percentage of records published by the Top 10 collaborators ranged from approximately 0.76 % (Australia) – 6.9 % (USA) for the period (2000-2005). The percentage of records published by the Top 10 collaborators ranged from approximately 0.85 % (Australia) – 6.9 % (USA) percent for (2005-2006). USA has remained as the most dominant collaborator for the entire period (1980-2006). In addition, Asian countries including Japan, Peoples Republic of China, and South Korea have recently significantly increased their respective bilateral and multilateral collaboration efforts with India.

- Further analysis indicates India and China are increasing their growth of articles in highly cited journals greater than their overall increase in growth of research articles. India’s relative increase is modest, whereas China’s increase is strong. For both countries, much of the increase in overall research article growth comes from increasing production of articles in low Impact Factor domestic and international journals. In addition, for both countries, there is increased production in high Impact Factor journals as well. The increase in high Impact Factor journals outpaces the increase in overall research article production, but the high Impact Factor journal production is a relatively small fraction of the overall research article production.

6.1.2 Prominent Journals

An analysis was performed to identify the prominent journals in which India authors publish (contain most India-authored research articles) and most cited journals. Aggregate journal citation metrics comprising total citations from all research articles retrieved from the SCI/SSCI database during the period (2005-2006) were compiled, including journal impact factors (measures of a journal's ability to attract citations). The Top 50 journals cited most frequently were identified, and reproduced in Table 9, sorted in order of decreasing citation frequency.

- A benchmark for journals containing the most research papers published by authors in India, USA, and China was established. The medians of the journal Impact Factors were calculated (USA: 4.74; China: 0.59; and India: 0.40 indicating that USA Impact Factors are an order of magnitude greater than those of China or India. It was also shown that collaboration has the effect of dramatically increasing the presence of papers with India authors in the higher Impact Factor journals.

- Analysis of aggregate journal citation metrics, for all research articles retrieved from the SCI/SSCI database during the period (2005-2006) indicates that the Impact Factors for the most cited journals are an order of magnitude higher than the impact factors of the journals that contain the most India papers. Thus, India authors are citing the high Impact Factor journals extensively, but not publishing in them extensively.

- Although India authors are increasing their presence in these high Impact Factor journals, they are presently over-concentrated in the lower Impact Factor journals.

- The most cited Indian (indigenous) journals are all distributed towards the lowest total of 2005 cites, and only account for approximately 1.3% (18,301) of the total 2005 cites (1,436,677).

TABLE 9. TOP 50 MOST CITED JOURNALS BY INDIAN AUTHORS

SCI / SSCI Journal Bibliometrics (2005 - 2006)							
Rank	JOURNALS	# Records	2005 Total Cites	Impact Factor	Immediacy Index	2005 Articles	Cited Half-Life
1	JOURNAL OF THE INDIAN ACADEMY OF PEDIATRICS*	167	NA	NA	NA	NA	5.9
2	PHYSICAL REVIEW LETTERS	193	250517	7.489	1.572	3694	>10.0
3	PHYSICAL REVIEW B	331	199350	3.185	0.609	6126	>10.0
4	JOURNAL OF CHEMICAL PHYSICS	164	148396	3.138	0.71	2902	8
5	APPLIED PHYSICS LETTERS	149	123517	4.127	0.551	4414	1.7
6	JOURNAL OF APPLIED PHYSICS	237	88927	2.498	0.363	3453	4.3
7	PHYSICAL REVIEW D	208	82935	4.852	1.749	2247	>10.0
8	TETRAHEDRON LETTERS	574	69531	2.477	0.532	1956	7.6
9	JOURNAL OF PHYSICAL CHEMISTRY B	204	59826	4.033	0.705	3121	>10.0
10	PHYSICS LETTERS B	135	55129	5.301	1.499	955	>10.0
11	PHYSICAL REVIEW E	165	48497	2.418	0.5	2525	>10.0
12	CHEMICAL PHYSICS LETTERS	167	48249	2.438	0.519	1393	7.7
13	TETRAHEDRON	184	39659	2.61	0.493	1222	7.8
14	JOURNAL OF COLLOID AND INTERFACE SCIENCE	135	24877	2.023	0.305	973	6.9
15	JOURNAL OF APPLIED POLYMER SCIENCE	428	24233	1.072	0.142	1142	8.8
16	JOURNAL OF PHYSICS-CONDENSED MATTER	142	22209	2.145	0.358	1172	9.2
17	JOURNAL OF MATERIALS SCIENCE	155	15674	0.901	0.088	831	5
18	MATERIALS SCIENCE AND ENGINEERING A-STRUCTURAL MATERIALS PROPERTIES MICROSTRUCTURE AND PROCESSING	151	15537	1.347	0.17	1196	7.7
19	INDUSTRIAL & ENGINEERING CHEMISTRY RESEARCH	135	15264	1.504	0.221	1106	6.9
20	BIOORGANIC & MEDICINAL CHEMISTRY LETTERS	155	14580	2.478	0.573	1076	5.2
21	NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS	159	12230	1.181	0.115	1341	5.2
22	PHYSICA B-CONDENSED MATTER	160	9394	0.796	0.14	1041	4.2
23	JOURNAL OF MOLECULAR CATALYSIS A-CHEMICAL	197	9227	2.348	0.417	599	7.5
24	BIOORGANIC & MEDICINAL CHEMISTRY	130	7484	2.286	0.577	662	>10.0
25	SYNTHETIC COMMUNICATIONS	202	6344	0.86	0.126	404	4.5
26	MOLECULAR AND CELLULAR BIOCHEMISTRY	156	6127	1.681	0.161	316	5.3
27	MATERIALS LETTERS	160	5812	1.299	0.173	873	6.6
28	SPECTROCHIMICA ACTA PART A-MOLECULAR AND BIOMOLECULAR SPECTROSCOPY	209	5613	1.29	0.17	593	8.5
29	BIORESOURCE TECHNOLOGY	147	4456	1.863	0.287	265	
30	CURRENT SCIENCE	774	3451	0.728	0.294	537	6.2
31	ACTA CRYSTALLOGRAPHICA SECTION E-STRUCTURE REPORTS ONLINE	547	3322	0.581	0.325	2849	7.4
32	INDIAN JOURNAL OF CHEMISTRY SECTION B-ORGANIC CHEMISTRY INCLUDING MEDICINAL CHEMISTRY	412	2284	0.446	0.055	271	NA
33	INDIAN JOURNAL OF CHEMISTRY SECTION A-INORGANIC BIO-INORGANIC PHYSICAL THEORETICAL & ANALYTICAL CHEMISTRY	255	2033	0.632	0.103	195	4.9
34	JOURNAL OF THE INDIAN CHEMICAL SOCIETY	472	1922	0.34	0.062	257	>10.0
35	INDIAN JOURNAL OF MEDICAL RESEARCH	137	1497	0.869	0.476	124	3.8
36	INDIAN JOURNAL OF ANIMAL SCIENCES	602	1051	0.09	0.016	312	5.7
37	JOURNAL OF THE GEOLOGICAL SOCIETY OF INDIA	197	850	0.217	0.08	150	6.2
38	INDIAN JOURNAL OF PURE & APPLIED PHYSICS	253	821	0.495	0.026	152	6.6
39	JOURNAL OF FOOD SCIENCE AND TECHNOLOGY-MYSORE	377	810	0.123	0	139	3.8
40	INDIAN VETERINARY JOURNAL	747	800	0.052	0.009	438	>10.0
41	PRAMANA-JOURNAL OF PHYSICS	248	781	0.38	0.153	216	5.5
42	BULLETIN OF MATERIALS SCIENCE	196	754	0.777	0.026	117	5.3
43	ASIAN JOURNAL OF CHEMISTRY	482	477	0.153	0.066	467	9.4
44	INDIAN JOURNAL OF AGRICULTURAL SCIENCES	406	470	0.084	0	153	5.3
45	JOURNAL OF SCIENTIFIC & INDUSTRIAL RESEARCH	184	453	0.232	0.016	123	5
46	INDIAN JOURNAL OF PHYSICS AND PROCEEDINGS OF THE INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE	286	342	0.072	0.02	202	>10.0
47	INDIAN JOURNAL OF CHEMICAL TECHNOLOGY	172	288	0.226	0.04	101	6.6
48	INDIAN JOURNAL OF HETEROCYCLIC CHEMISTRY	207	287	0.312	0.024	127	9.2
49	JOURNAL OF ENVIRONMENTAL BIOLOGY	134	229	0.34	0	119	7.4
50	TRANSACTIONS OF THE INDIAN INSTITUTE OF METALS	148	161	0.215	0.017	116	5.3

6.1.3 Prolific Affiliations

Detailed bibliometric analysis results identified not only the most prolific affiliations associated with India authors, but also which affiliations collaborate significantly on research publications. The analysis specifically identified these most prolific affiliations (institutions) and their collaboration linkages (based on total number of articles) through use of several methods including:

1) Affiliation Co-occurrence Matrices
2) Affiliation Auto-correlation Maps
3) Affiliation Factor Matrices, and

Additional methods are employed to identify specific affiliation collaboration linkages (based on common terminology and Journals) including:

4) Affiliation - Phrase Co-occurrence Matrices
5) Affiliation x Phrase Cross-correlation Maps
6) Affiliation - Journal Co-occurrence Matrices

These analysis methods provided progressive insight into the nature or attributes of specific research collaboration groups (links), and allowed detailed correlation analysis between research article attributes (data fields) including authors, affiliations, subject categories, keywords and journals. The analysis results indicate the following:

- Affiliation - Phrase cross-correlation maps and Affiliation auto-correlation maps (2005-2006) show central cores of Indian research based on common terminology, with the more basic research centered about the Indian Institute of Science and the more applied research centered about the Indian Institute of Technology (IIT).

- Numerous technically based groupings can be discerned from both the generic and detailed phrase SCI/SSCI cross-correlation maps including:

    - A large chemistry-oriented group that includes several IIT chemistry departments, the Central Drug Research Institute and several leading universities; and
    - A strong linkage at the bottom between the Tata Institute of Fundamental Research and the Institute of Theoretical and Experimental Physics, Moscow.

- The EC and INSPEC cross-correlation structure includes a large applied chemistry-oriented group (center) that includes several IIT and Indian Institute of Science chemistry departments, Central Electrochemical Research Institute and several leading universities.

6.1.4 Collaborative Countries

The predominant countries listed with India in all SCI/SSCI research articles for the periods (1980-2005) and (2005-2006) were identified and ranked based on total number of articles. Figure 30 reproduced below, illustrates the trend for the period (1980-2005).

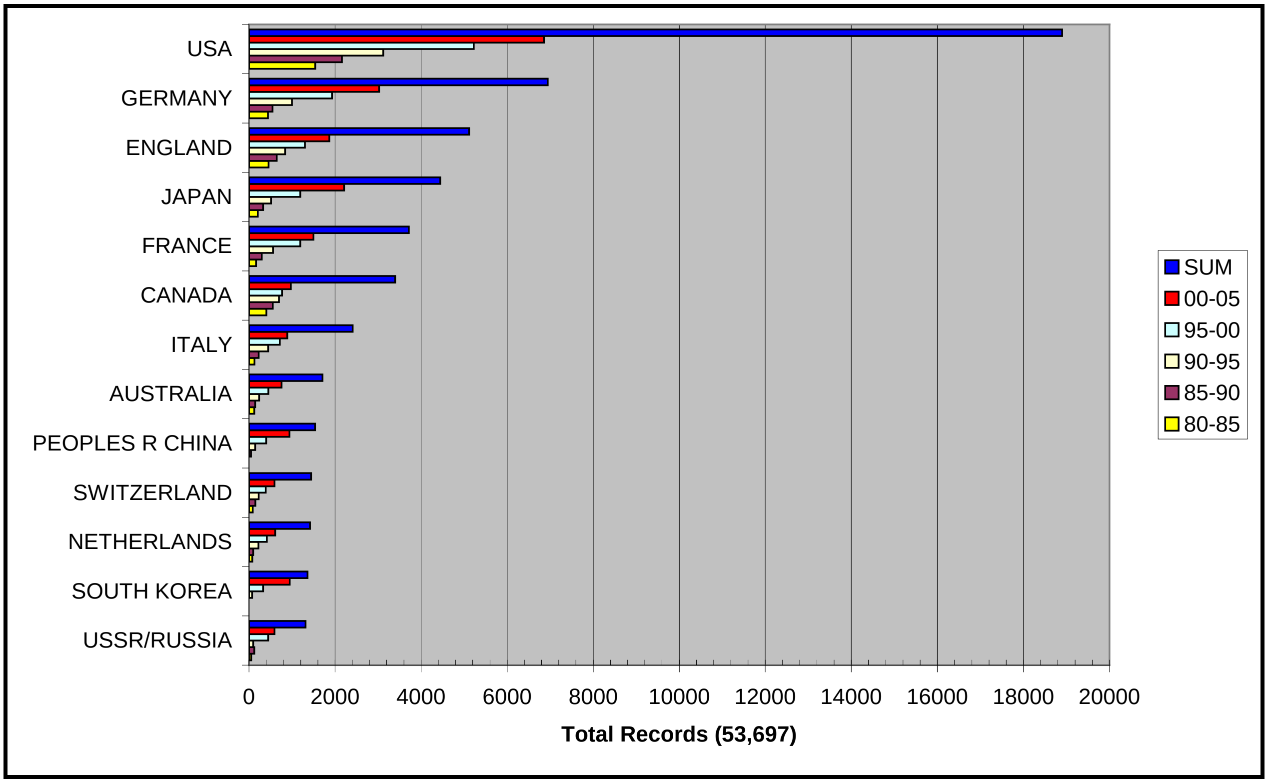

Figure 30. Predominant (Top 10) SCI/SSCI Country Collaboration for (1980 - 2005)

- USA has remained as the most dominant collaborator for the entire period.
- Asian countries including Japan, Peoples Republic of China, and South Korea have recently significantly increased their collaboration efforts.
- The summation of records published for all collaborators ranged from approximately 1,315 (USSR/Russia) – 18,900 (USA). Many of the countries listed in Figure 30 are far smaller than India, yet their current research outputs now are quite similar in magnitude, and their growths have been dramatic.

During the preceding study, the SCI/SSCI database was accessed in March 2006 to identify the main collaborating countries with India on research articles, for the period (2004-2005). For comparative purposes, this study provides updated journal citation report (JCR) data, accessed in March 2007, for the period (2005-2006). The results for both periods are provided below in Table 18, and summarized as follows:

- All collaborative countries account for approximately 22% of the total records published for both given periods, with USA as the predominant collaborator (total records = 6,790 or approximately 31% of the total records for all collaborative countries).

- Collaborative research (based on co-authorship) with USA and China is being published in relatively high IF journals. The average Top 25 journal IF = 3.159 for India and USA; and 1.716 for India and China co-authorship, respectively.

TABLE 18. SCI/SSCI MAIN COLLABORATING COUNTRY COMPARISON

Country	Records 2004-2005	Times Cited 2004-2005	Records 2005-2006	Times Cited 2005-2006	Average Cites Per Record	Average Cites Per Year
USA	3,182	5,824	3,608	13,158	3.81	4,667
Germany	1,439	2,928	1,534	6,449	4.45	2,298
Japan	1,046	2,419	1,206	5,179	4.59	1,850
England	877	2,024	1,034	4,647	4.91	1,652
France	712	1,901	852	4,515	5.99	1,598
South Korea	552	1,439	689	3,095	5.14	1,104
China	521	1,891	586	3,987	7.40	1,420
Canada	435	521	526	1,486	3.54	514
Italy	422	1,013	451	2,158	5.15	790
Australia	384	1,396	442	2,430	5.96	899
Russia	316	1,833	349	3,412	10.88	1,242
Spain	268	586	292	1,307	5.22	466
India (only)	46,251	NA > 10,000	52,047	NA > 10,000	NA > 10,000	NA > 10,000

6.2 Taxonomies - Document Clustering

The pervasive technical themes of India's research, the relationships among those themes, and the levels of emphasis (number of research articles published) associated with each of the themes were identified. The analyses used a document clustering approach, based on favorable results from previous text mining studies. Document clustering is the grouping of similar research articles into thematic categories that can be depicted as a hierarchical tree representing the overall taxonomy of India's research.

6.2.1 Document Clustering Results

Detailed clustering analysis was performed individually for the SCI/SSCI, EC and INSPEC (2005-2006) databases providing matrices that synopsized of the first four levels of the SCI/SSCI, EC and INSPEC hierarchical taxonomies, where each cell in a matrix lists representative technical categories. Based on raw cluster data including themes, keywords and journal titles; an extended analysis was performed to identify primary (**BLACK**), secondary (blue) and tertiary (red) category headings for each taxonomy. Table 45 provides a comparative listing of the SCI/SSCI, EC and INSPEC (Level 4) hierarchical taxonomies. For comparison, Table 45 also lists the taxonomy for the SCI/SSCI database (2005) obtained during the preceding India S&T literature assessment. As expected, the overall hierarchical taxonomies were essentially maintained between SCI/SSCI (2005) and SCI/SSCI (2005-2006) datasets even by just comparing the primary category headings.

TABLE 45. COMBINED SCI/SSCI, EC AND INSPEC LEVEL 4 TAXONOMIES

SCI/SSCI LEVEL 4 (2005)	SCI/SSCI LEVEL 4 (2005-2006)	EC LEVEL 4 (2005-2006)	INSPEC LEVEL 4 (2005-2006)
CLINICAL MEDICINE 758 records	Cluster {358} - 578 records clinical medicine neurology and neuroscience surgery pathology *dermatology* *radiology* *oral medicine*	Cluster {485} - 909 records chemical synthesis colloid and interface science reaction kinetics surface active agents / surfactants *polymerization* *monomers*	Cluster {233} - 1,789 records information technology scientific and industrial research *inventory and supply chain management* *genetic algorithms* *food processing technology*
	Cluster {405} - 839 records clinical medicine neurology and neuroscience surgery *cataract and refractive surgery* *thoracic surgery* *anesthesia and analgesia* *neuroradiology and neurosurgery*	Cluster {474} - 865 records colloid and interface science reaction kinetics surface active agents / surfactants *separation and purification techniques* *chromatography*	Cluster {240} - 1,852 records scientific and industrial research information technology signal and image processing *pattern recognition and machine intelligence* *data mining*
HUMAN PATIENT DISEASES 758 records	Cluster {276} - 204 records clinical medicine human patient diseases pathology oncology *cytology and cytopathology*	Cluster {481} - 1,216 records organic compounds chemical synthesis molecular catalysis *chemical oxidation and reaction kinetics* *catalysts / organic solvents*	Cluster {213} - 850 records telecommunications wireless sensor networks photonic sensor networks *cryptography*
	Cluster {339} - 1,204 records clinical medicine human patient diseases pathology *gastroenterology* *dermatology* *hematology* *tropical medicine and hygiene*	Cluster {487} - 1,313 records organic compounds chemical synthesis molecular organic crystals *molecular and crystal structure* *molecular and biomolecular spectroscopy*	Cluster {30} - 236 records scientific and industrial research information technology signal and image processing *pattern recognition and machine intelligence* *genetic algorithms* *artificial intelligence*
GEOLOGICAL RESEARCH MATERIAL MECHANICS 717 records	Cluster {495} - 4,225 records environmental sciences plant sciences geology plant biochemistry and biotechnology *geophysical research*	Cluster {488} - 1,963 records chemical synthesis/doping polycrystalline and nanostructured materials *ferroelectric and magnetic materials*	Cluster {189} - 431 records electric power systems and components electric power distribution and control *linear and non-linear control systems* *smart materials*
PLANT BIOLOGY 807 records	Cluster {489} - 3,316 records molecular and cellular biochemistry microbiology and biotechnology plant sciences *plant biochemistry and biotechnology*	Cluster {496} - 2,272 records chemical synthesis/doping polycrystalline and nanostructured materials crystal structure and growth research *single crystals and surface coatings* *x ray diffraction*	Cluster {200} - 546 records electric power systems and components electric power distribution and control *fuzzy and intelligent control* *computer simulation*
CELL BIOLOGY GENETICS 1,168 records	Cluster {462} - 1,951 records molecular and cellular biochemistry microbiology and biotechnology plant sciences *ethnopharmacology* *phytotherapy research* *medicinal food* *toxicology and pharmacology*	Cluster {361} - 533 records polycrystalline and nanostructured materials thin solid films solar energy / solar cell research *deposition techniques* *optical properties*	Cluster {221} - 707 records solid-state / semi-conductor materials and devices microelectronics *VLSI Circuit Design*
SOIL/CROP EXPERIMENTS 952 records	Cluster {494} - 3,835 records microbiology and biotechnology environmental biology plant sciences *agricultural and food chemistry* *agronomy*	Cluster {310} - 385 records nanostructured materials thin solid films solid-state/semi-conductor materials *electrochemistry and electrodeposition* *sol-gels*	Cluster {11} - 188 records microwave and optical technology microwave/microstrip antenna design *radio space physics* *electromagnetic wave propagation*
ALGORITHMS NETWORK MODELING 1,372 records	Cluster {484} - 3,719 records scientific and industrial research pattern recognition and machine intelligence *electric power components and systems* *applied computing and internet technology* *production and operational research*	Cluster {498} - 2,310 records organic compounds *polymer composites and plastics* *materials characterization* *microstructure and material properties*	Cluster {211} - 838 records chemical engineering physics of fluids computational fluid dynamics *plasma physics* *magnetohydrodynamics* *heat mass transfer*
MOLECULAR LEVEL CALCULATIONS 1,064 records	Cluster {497} - 7,844 records astronomy and astrophysics nuclear and particle physics *plasma physics* *high energy physics*	Cluster {502} - 3,997 records microbiology and biotechnology agronomy / plant and food sciences environmental biology *plant biochemistry and biotechnology* *genetic resources and crop evolution* *environmental monitoring and impact assessment* *rain/ground wat*	Cluster {216} - 818 records structural design and analysis *composites and plastics* *finite element analysis*
CONTINUUM ANAYSIS 1,255 records	Cluster {499} - 4,806 records thin solid films crystal growth research and technology *nanoscience and nanotechnology* *optoelectronics* *superconductor science and technology*	Cluster {470} - 1,178 records chemical engineering mathematical models and computer simulation computational fluid dynamics *heat mass transfer*	Cluster {229} - 1,731 records nuclear and particle physics astronomy and astrophysics *plasma physics* *radio space physics* *cosmology*
FILM PHYSICS 1,576 records	Cluster {498} - 5,745 records physical chemistry hazardous materials *chemical technology* *colloid and interface science* *membrane separation and purification technology*	Cluster {489} - 2,169 records mathematical models and computer simulation computational fluid dynamics *microwave optics* *plasma physics* *Monte Carlo and molecular dynamics*	Cluster {242} - 1,517 records astronomy and astrophysics *plasma physics* *radio space physics* *cosmology* *earthquake and seismology research*
FILM CHEMISTRY 1,291 records	Cluster {496} - 3,613 records physical chemistry molecular liquids *nano-metal chemistry* *colloid and interface science*	Cluster {476} - 975 records mathematical models and computer simulation telecommunications microelectronics *VLSI Circuit Design*	Cluster {241} - 1,526 records organic compounds crystal growth polycrystalline and nanostructured materials molecular organic crystals *molecular and biomolecular spectroscopy* *x-ray diffraction analysis*
CHEMICAL BONDING / CRYSTAL STRUCTURES 939 records	Cluster {0} - 484 records inorganic chemistry physical chemistry crystal growth research and technology *crystallography* *crystal growth and design* *radiation physics and chemistry*	Cluster {458} - 655 records mathematical models and computer simulation electrical power and distribution systems *fuzzy and intelligent control* *instruments and measurement*	Cluster {236} - 1,563 records solid-state/semi-conductor materials and devices ferromagnetic materials *x-ray diffraction analysis* *electron/atomic force microscopy* *superconductor science and technology*
ANIMAL EXPERIMENTS 651records	Cluster {445} - 1,926 records molecular and cellular biochemistry organic and biomolecular chemistry *heterocyclic chemistry* *bioorganic and medicinal chemistry* *pharmaceutical research*	Cluster {483} - 1,004 records mathematical models and computer simulation telecommunications artificial intelligence wireless telecommunication networks *neural networks* *wireless network optimization*	Cluster {199} - 1,091 records thin solid films solid-state/semi-conductor materials and devices *x-ray diffraction analysis* *electron/atomic force microscopy* *solar energy / solar cell research*
REACTIONS/CATALYSIS/SYNTHESIS 1,298 records	Cluster {481} - 2,530 records physical chemistry molecular and cellular biochemistry molecular synthesis and catalysis *chemical science and kinetics* *medicinal chemistry*	Cluster {493} - 1,840 records mathematical models and computer simulation pattern recognition and machine intelligence artificial intelligence *genetic algorithms* *intelligent remote sensing* *information retrieval / data mining*	Cluster {245} - 3,168 records organic compounds *polymer science and technology* *composites and plastics* *microstructure and material properties*

- The respective taxonomies generated by the CLUTO clustering algorithm essentially paralleled the subject coverage areas for each database.

- The taxonomies generated for the EC and INSPEC databases reflect more focus on Applied Physical Sciences, Materials Engineering, Electrical Engineering, and Electronics.

6.2.2 Extended India Research Collaboration Analysis - Solid Thin Films

The document clustering results obtained for the SCI/SSCI, EC, and INSPEC databases (Level 4 Clusters) for the period (2005-2006) identified themes or single technology focus areas of India research. The results (total records) for SCI/SSCI (Cluster {499}), EC (Clusters {310, 361}) and INSPEC (Cluster {199}) indicate that solid thin films is one viable single technology focus area that warrants extended research collaboration analyses. Therefore, a generalized single technology query was developed to retrieve the maximum number of records from each database focused on solid thin film research.

The expanded thin film query includes select search terms that are primarily associated with large substrate thin film deposition processes, and limited specific materials such as including amorphous silicon and crystalline silicon used in semiconductor applications. Specifically, the analyses focus on India thin film research (indigenous and collaborative) with the United States (USA) and Peoples Republic of China.

Table 31 reproduced below, lists the total articles retrieved using the Thin Film AND India address query, and total articles retrieved using the India address (ONLY) query from the SCI/SSCI, EC and INSPEC databases for the period (1980-2006). Table 31 also lists the respective ratio of total articles retrieved using these queries for each database. Table 32 lists the total article publication and average Top 10 Journal IF Trends for each database.

TABLE 31. SCI/SSCI, EC AND INSPEC (1980-2006) COMPARATIVE TOTAL PUBLICATION TREND (THIN FILM QUERY AND INDIA) / (INDIA ONLY)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06	80-06
SCI/SSCI Total Records (India ONLY)	64600	67416	73202	92909	100000	52047	398127
SCI/SSCI Total Records (Thin Film AND India)	1024	1286	3,447	5,651	8,789	4,429	20197
SCI/SSCI Total Record Ratio (Thin Film AND India / India)	1.59%	1.91%	4.71%	6.08%	8.79%	8.51%	5.07%
EC	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**	**80-06**
EC Total Records (India ONLY)	22728	22941	20104	31735	53360	24,475	150868
EC Total Records (Thin Film AND India)	1834	2101	2193	3531	6034	3004	15693
EC Total Record Ratio (Thin Film AND India / India)	8.07%	9.16%	10.91%	11.13%	11.31%	12.27%	10.40%
INSPEC	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**	**80-06**
INSPEC Total Records (India ONLY)	28506	30606	33246	34612	45056	18988	172026
INSPEC Total Records (Thin Film AND India)	1945	2487	3157	3910	5319	2498	16818
INSPEC Total Record Ratio (Thin Film AND India / India)	6.82%	8.13%	9.50%	11.30%	11.81%	13.16%	9.78%

TABLE 32. COMPARATIVE TOTAL PUBLICATION AND AVERAGE TOP 10 JOURNAL IF TRENDS (SCI/SSCI, EC AND INSPEC (1980-2006)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	1024	1286	3,447	5,651	8,789	4,429
Top 10 Journal Records	482	566	945	1286	1690	856
Ratio (Top 10 Journal Records / Total Records)	47.07%	44.01%	27.42%	22.76%	19.23%	19.33%
Average Top 10 Journal IF	1.362	1.614	1.705	1.664	1.811	2.223
EC	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	1834	2101	2193	3531	6034	3004
Top 10 Journal Records	662	750	692	1054	1394	656
Ratio (Top 10 Journal Records / Total Records)	36.10%	35.70%	31.55%	29.85%	23.10%	21.84%
Average Top 10 Journal IF	1.657	1.192	1.290	1.174	1.422	1.723
INSPEC	80-85	85-90	90-95	95-00	00-05	05-06
Total Records	1945	2487	3157	3910	5319	2498
Top 10 Journal Records	761	875	1019	1131	1290	659
Ratio (Top 10 Journal Records / Total Records)	39.13%	35.18%	32.28%	28.93%	24.25%	26.38%
Average Top 10 Journal IF	0.875	0.976	2.029	2.100	1.738	1.401

Comprehensive review of the thin film research analyses indicates the following:

- The extent (scope) of India thin film research in terms of overall indigenous output production in a given time period (1980-2006) is determined by total publication trends. These trends indicate a steady publication growth rate during the entire period that has rapidly exceeded 10.4 % for the recent period (2005-2006). Indigenous research output contains only Indian authors.

- The extent of India thin film research collaboration with both the USA and China in terms of overall output production in the period (1990-2006), is determined by the total publication and article citation trends that show steady growth rates during the entire period. The USA has a significantly greater output production compared to India.

- Collaborative thin film research with USA and China authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to indigenous research being published by only India authors.

- The specific Journals or Conference Proceedings comprising indigenous India thin film research articles is a broad collection of journals with varying citations and impact factors. The ratio of articles published in the Top 10 Journals to total articles ranges between 19-26 percent and the average Top 10 Journal impact factors ranges between 1.4 and 2.3, for all databases during the period (2005-2006). The more prominent Journals listed by total article contribution included:

    - JOURNAL OF APPLIED PHYSICS
    - JOURNAL OF MATERIALS SCIENCE
    - JOURNAL OF APPLIED POLYMER SCIENCE
    - JOURNAL OF PHYSICAL CHEMISTRY B
    - THIN SOLID FILMS
    - APPLIED SURFACE SCIENCE
    - SOLAR ENERGY MATERIALS AND SOLAR CELLS
    - SURFACE COATINGS TECHNOLOGY

- Primary collaborating countries other than the USA or China included Germany, Japan, South Korea, France, Taiwan, England, Switzerland and Italy.

- The utility of thin film collaborative research as related to article citations and associated Journal impact factors was determined. The collaborative research is published in higher cited journals, with greater average cites per article and impact factors compared to research being published with only India authors. However, based on use of the Thin Film AND India address ONLY query, the ratio of total citations for the Top 1% and Top 5% of articles retrieved to total citations shows a dramatic growth rate for the period (2005-2006). The citation rate for the Top 1% and Top 5% of these articles is extremely high in comparison to the entire preceding period (1980-2005), suggesting that the overall growth rate and utility of thin film research within India is increasing and is being recognized and cited by international researchers.

- Thin film collaborative research is being performed by numerous Indian authors and their respective affiliations. The Top 25 author affiliations involved in thin film research account for approximately 72% of the total articles retrieved from the SCI/SSCI database, and approximately 17% from the EC and INSPEC databases. The collaborative linkages/groups are clearly shown by the author affiliation auto-correlation maps for each database.

- Prominent Indian (indigenous) thin film research focus areas and publication topics identified from all databases include:

    1. Development of fast ion beam sources for engineering the micro- and nanostructural properties of thin films. Focus is on metallic and rare earth ion beams that have

important roles in nano-technology and enhancement of optical properties of semiconductor nano-particles inside various matrices.

2. Polycrystalline and nanoparticle thin film formation using vacuum evaporation and inert gas evaporation techniques, respectively.
3. Amorphous thin films formation using thermal evaporation
4. Multilayer heterostructural thin film formation using e-beam evaporation techniques to synthesize metallic contacts for nanoscale devices (nanomixing). Swift ion sources are then used to tailor micro- and nanostructural properties.
5. Thin film formation using sol-gel techniques and characterization of structural and dielectric properties using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), AC conductivity techniques.

- Prominent thin film research focus areas and publication topics identified for articles containing both India and Peoples Republic of China author addresses include:

1. Thermally grown ultra-thin silicon dioxide (SiO2) films and characterization of stress-induced leakage currents (SILC) using stressing and sensing measurements. Experimental results provide physical insight into the conduction mechanism of SILC through ultra-thin SiO2 films stressed in the direct tunneling (DT) regime.
2. Development of carbon nanotubes (CNTs) and carbon nanofibers (CNFs) using thermal CVD processes. These materials were used as the electrode platinum support for fuel cell evaluations.
3. Development of metal-oxide-semiconductor (MOS) structures with hafnium oxide as the gate dielectric film, and the investigation of current-voltage (I-V) characteristics.

- Prominent thin film research focus areas and publication topics identified for articles containing both India and USA author addresses include:

1. Development of Zn1-xMnxO thin films grown on Al2O3 and MgO substrates, and investigation of ferromagnetic behavior, and spin polarization of charge carriers. These single-phase films are being characterized for magnetic semiconductor applications.
2. Development of Cr-doped In2O3 thin films with tunable ferromagnetic behavior over a wide range of doping, or by electrical gating, is being investigated towards realizing spin electronics in magnetic semiconductors and developing spin-based multifunctional devices.
3. Development of amorphous superconducting films driven normal by a perpendicular magnetic field, and investigation of low-temperature behavior.

- The articles retrieved using the Thin Film AND INDIA address query from all databases indicates India is conducting research for a wide breadth of applications. The overall taxonomy of thin film collaborative research in terms of predominant generalized subject categories includes Materials Science, Physics, Physical Chemistry, Coatings and Films and Electrochemistry. These broad categories account for 90-100% of the total articles retrieved from each database for the period (2005-2006).

A final perspective on countries that dominated globally in thin film research output over the period (1980-2006) is illustrated by the total publication trends in Figure 74b, reproduced below.

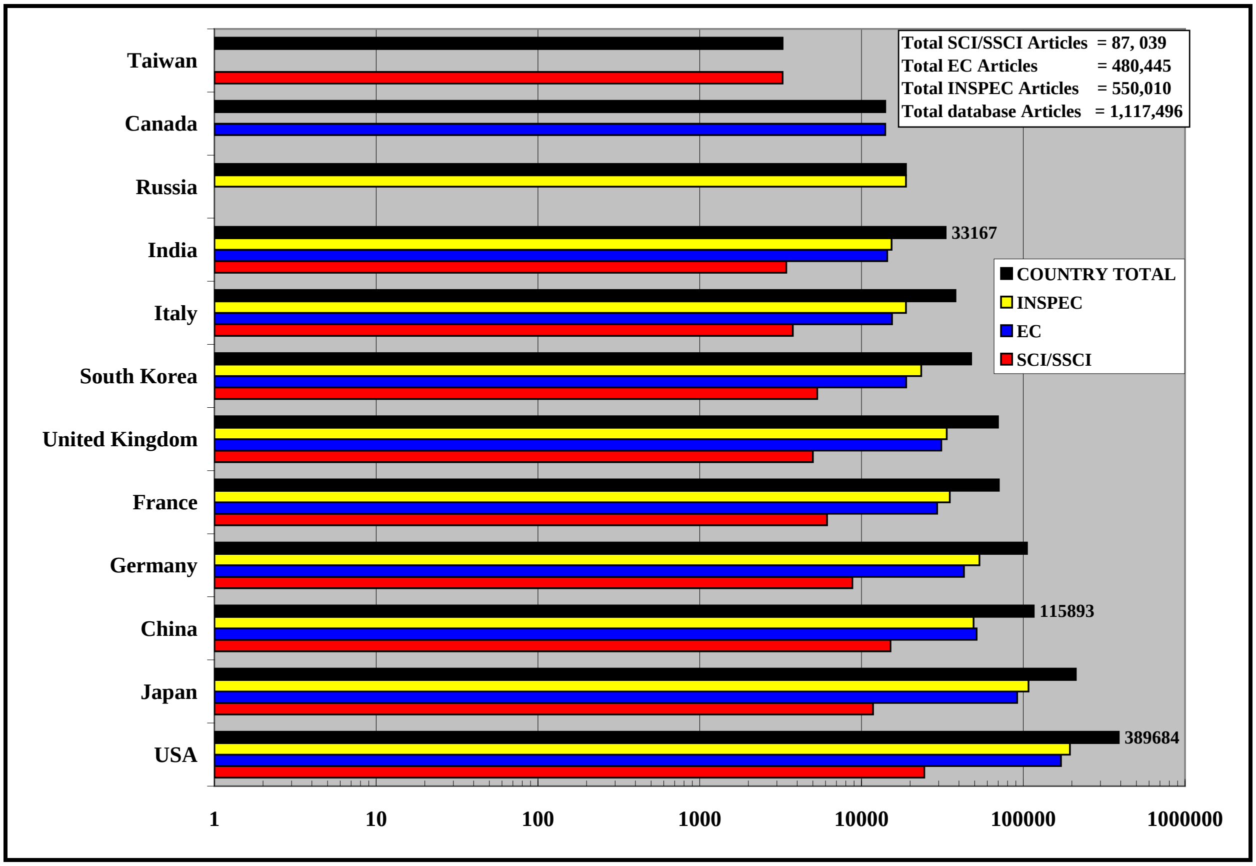

Figure 74b. Comparative Country Thin Film Publication Trends (1980-2006)
Thin Film (ONLY) Query

Figure 74b illustrates several important factors worth noting:

- The USA as the leader in total publications in all databases (ranked 1st @ 389,684 articles) over the entire period.
- The total publications for the Peoples Republic of China (ranked 3rd @ 115,893 articles), is approximately 30% of the total for the USA.
- The total publications for India (ranked 9th @ 33,167 articles), is approximately 9% of the total for the USA. Thus, from a global perspective, India is prominent, in terms of both indigenous and collaborative thin film research output, and ranked in the Top 10 nations. Analysis provided above indicated that the predominant countries collaborating with India on thin film research over this period include in order; USA, Germany, France, Japan South Korea, Italy, Taiwan, Peoples R China (2nd in publications), and the United Kingdom.

6.2.3 Extended India Research Collaboration Analysis – Crops/Soil

The document clustering results obtained for the SCI/SSCI, EC, and INSPEC databases (Level 4 Clusters) for the period (2005-2006) identified themes or single technology focus areas of India research. The results (total records) for SCI/SSCI Cluster {494}, EC Cluster {502} and INSPEC Cluster {233} indicate that crops/soil (agronomy) research is one viable single focus area that warrants extended research collaboration analyses.

This result was also identified during the preceding study that provided a similar analysis based on the development of a generalized single technology query for crops/soil (agronomy) research. The query uses topic search terms derived from detailed analysis of document clustering results, with specific focus on themes, keywords, technical phrases, article titles (leaf clusters) and journal information produced by the CLUTO clustering algorithm.

Therefore, this query was used to retrieve the maximum number of records from each database in order to provide an update to the preceding study, and to conduct extended research collaboration analyses focused on crops/soil research. Specifically, the analyses focus on India crops/soil research (indigenous and collaborative) with the United States (USA) and Peoples Republic of China.

Table 41 reproduced below, lists the total articles retrieved using the Crops AND India address query, and total articles retrieved using the India address (ONLY) query from the SCI/SSCI, EC and INSPEC databases for the period (1980-2006). Table 41 also lists the respective ratio of total articles retrieved using these queries for each database. Table 42 lists the total article publication and average Top 10 Journal IF Trends for each database.

TABLE 41. SCI/SSCI, EC AND INSPEC (1980-2006) COMPARATIVE TOTAL PUBLICATION TREND (CROPS AND INDIA QUERY) / (INDIA ONLY)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06	80-05
SCI/SSCI Total Records (India Only)	64600	67416	73202	92909	100000	52047	398127
SCI/SSCI Total Records (Crops AND India)	2729	2794	3949	4929	5,980	2,300	20381
SCI/SSCI Total Record Ratio (Crops AND India / India)	0.042	0.041	0.054	0.053	0.060	0.044	0.051
Engineering Compendex (EC)	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**	**80-05**
EC Total Records (India Only)	22728	22941	20104	31735	53505	25304	151013
EC Total Records (Crops AND India)	629	824	626	913	2057	982	5049
EC Total Record Ratio (Crops AND India / India)	0.028	0.036	0.031	0.029	0.038	0.039	0.033
INSPEC	**80-85**	**85-90**	**90-95**	**95-00**	**00-05**	**05-06**	**80-05**
INSPEC Total Records (India Only)	28506	30606	33246	34624	45171	20860	172153
INSPEC Total Records (Crops AND India)	192	136	189	186	338	220	1041
INSPEC Total Record Ratio (Crops AND India / India)	0.007	0.004	0.006	0.005	0.007	0.011	0.006

TABLE 42. COMPARATIVE TOTAL PUBLICATION AND AVERAGE TOP 10 JOURNAL IF TRENDS (SCI/SSCI, EC AND INSPEC (1980-2006)

SCI/SSCI	80-85	85-90	90-95	95-00	00-05	05-06	80-05
Total Records	2729	2794	3949	4929	5980	2300	19059
Top 10 Journal Records	1237	1156	1500	2058	2171	705	6,889
Ratio (Top 10 Journal Records / Total Records)	0.453	0.414	0.380	0.418	0.363	0.307	0.361
Average Journal IF	1.057	0.556	0.625	0.833	1.072	1.052	0.990
Engineering Compendex (EC)	80-85	85-90	90-95	95-00	00-05	05-06	80-05
Total Records	629	824	626	913	2057	982	5063
Top 10 Journal Records	214	341	168	371	769	337	1411
Ratio (Top 10 Journal Records / Total Records)	0.340	0.414	0.268	0.406	0.374	0.343	0.279
Average Journal IF	0.178	1.639	1.332	1.340	1.234	1.496	1.340
INSPEC	80-85	85-90	90-95	95-00	00-05	05-06	80-05
Total Records	192	136	189	186	338	220	1261
Top 10 Journal Records	53	66	57	46	117	90	429
Ratio (Top 10 Journal Records / Total Records)	0.276	0.485	0.302	0.247	0.346	0.409	0.340
Average Journal IF	1.431	0.935	0.834	1.109	0.830	0.978	1.224

Comprehensive review of the crops/soil research analyses indicates the following:

- The extent (scope) of Indian crops/soil research in terms of overall output production in a given period (1980-2006) is determined by the total publication trends. These trends further indicate a steady publication growth rate during the entire period (1980-2006).
- The extent of India crops research collaboration with both the USA and China in terms of overall output production in a given period (1990-2006), is determined by the total publication trends. The total publication and article citation trends show steady growth rates during the entire period. The USA has a significantly greater output production (published articles) compared to India.
- Collaborative crops/soil research with USA and China authors is being published in higher cited journals, with greater average cites per article and impact factors, compared to indigenous research being published by only India authors.

- The specific Journals or Conference Proceedings comprising indigenous India crops/soil research publications is a broad collection of literature journals with varying citations and impact factors, as indicated by the bibliometric trends.

- Primary collaborating countries other than the USA or China identified from the SCI/SSCI database for the entire period (1980-2006) include United Kingdom, Philippines, Germany, Australia, Japan, Canada, and Netherlands.

- The utility of India crops/soil collaborative research as related to article citations and associated Journal impact factors was determined. The collaborative research is published in higher cited journals, with greater average cites per article and impact factors compared to research being published with only India authors. However, the ratio of total citations for the Top 1% and Top 5% of the most cited articles retrieved to total citations of ALL articles shows a dramatic growth rate for the period (2005-2006). The citation rate for the Top 1% and Top 5% of these articles is extremely high in comparison to the entire preceding period (1980-2005), suggesting that the overall growth rate and utility of crops research within India is increasing and is being recognized and cited by international researchers.

- Prominent Indian (indigenous) crops/soil research focus areas and publication topics identified from all databases include:

  1. The map-based sequence of the rice genome is being investigated under the International Rice Genome Sequencing Project. Rice, one of the world's most important food plants, has important syntenic relationships with the other cereal species and is a model plant for the grasses. The map-based sequence has proven useful for the identification of genes underlying agronomic traits and could accelerate improvements in rice production.
  2. Case studies to assess the long-term effect of sewage irrigation on heavy metal content in soils, plants and groundwater. The gradual decline in availability of fresh water to be used for irrigation in India demands the use of sewage and other industrial effluents for irrigating agricultural lands.
  3. Development of separation and purification technology for removal and recovery of malachite green from wastewater using an agricultural waste material, de-oiled soya. De-oiled soya is a waste product obtained during the processing of soyabean in soya oil extraction mills. Attempts are being made to exploit this crop as waste material and low cost adsorbent for the removal of toxic textile dye 'malachite green'.
  4. Bottom ash, a power plant waste, and de-oiled soya, an agricultural waste material, is also being used for removal and recovery of *Amaranth* and Quinoline Yellow water-soluble *hazardous* dyes.

- Prominent crops/soil research focus areas and publication topics were identified for articles containing both India and China addresses including:

  1. Collaboration on the International Rice Genome Sequencing Project to investigate the map-based sequence of the rice genome (see above).

2. Collaboration on the Tomato Sequencing Project, the first cornerstone of the International Solanaceae Project (SOL) (see above).
3. Investigation of water saving for sustaining and increasing the productivity of rice-wheat systems. Current technologies for reducing irrigation water requirements include laser leveling, direct drilling, raised beds, non-ponded rice culture and irrigation scheduling. Studies indicate that rehabilitation and improvement of canal and power systems in Asia are required to facilitate adoption of many water saving technologies.

- Lastly, prominent crops/soil research focus areas and publication topics were identified for articles containing both India and USA addresses including:

1. Collaboration on the International Rice Genome Sequencing Project to investigate the map-based sequence of the rice genome (see above).
2. Collaboration on the Tomato Sequencing Project, the first cornerstone of the International Solanaceae Project (SOL) (see above).
3. Investigation and modeling of Greenhouse gas emissions (simulate methane (CH4), nitrous oxide (N2O) and carbon dioxide (CO2)) from Indian rice fields using various management practices. The study suggested models could be applied for estimating the gas emissions and the influences of agronomic management, soil and climatic parameters.
4. Investigations of the adoption of bacillus thuringiensis (Bt) cotton and impact variability, based on insights from India. There is a growing body of literature on the impacts of Bt cotton in developing countries, and these studies focus on explaining paradoxes in recent controversy over genetically modified crops. The studies indicate that apart from differences in pest pressure and patterns of pesticide use, germplasm effects can play an important role. Theoretical arguments are supported by empirical evidence from India.

A final perspective on countries that dominated globally in crops/soil research output over the period (1980-2006) is illustrated by the total publication trends in Figure 84, reproduced below.

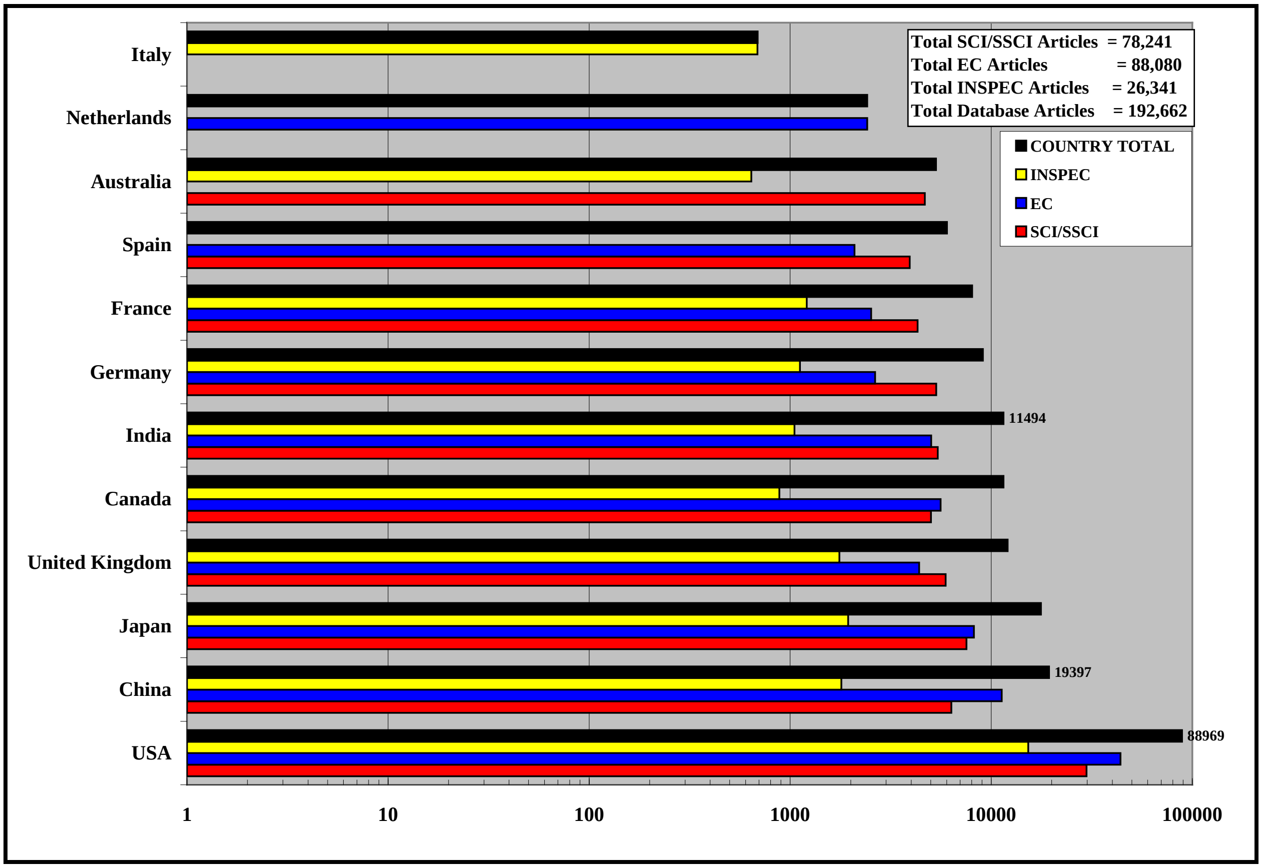

Figure 84. Comparative Country Thin Film Publication Trends (1980-2006)
Crops (ONLY) Query

Figure 84 illustrates several important factors worth noting:

- USA is the leader in total publications in all databases (ranked 1st @ 88,969 articles) over the entire period.
- The total publications for the Peoples Republic of China (ranked 2nd @ 19,397 articles), is approximately 22% of the total for the USA.
- The total publications for India (ranked 6th @ 11,494 articles), is approximately 13% of the total for the USA. Thus, from a global perspective, India is prominent, in terms of both indigenous and collaborative thin film research output, and ranked highly in the Top 10 nations.
- Predominant countries collaborating with India on crops/soil (agronomy) research over this period include in order; USA, Germany, United Kingdom, South Korea, Australia, Peoples R China (2nd in publications), Philippines, Japan, France, and Netherlands.
- The articles retrieved using the expanded crops AND INDIA address query from all databases indicates that India is conducting crops/soil research for a wide breadth of applications. The overall taxonomy of crops/soil research (indigenous and collaborative) in terms of predominant generalized subject categories comprises agronomy, plant sciences, microbiology and biotechnology, environmental biology, genetic resources and crop evolution, and food processing technology.

6.2.4 Extended India Research Collaboration Analysis - Subject Categories

The extended India research collaboration analysis for subject categories provides a final perspective of the nature of India collaborative research with the USA and Peoples Republic of China by determining the impact (effects) of collaboration on the overall regarded utility of the research based on article citations and associated Journal impact factors. Specifically, the analysis uses several Country address queries to determine if these effects are evident across a much broader, generalized taxonomy of India research, as opposed to the single-technology level. Figure 96 reproduced below, illustrates the comparative subject category average citation trends (all articles) for India, China, and India with China. Figure 97 illustrates the comparative trends for India, USA, and India with USA, respectively.

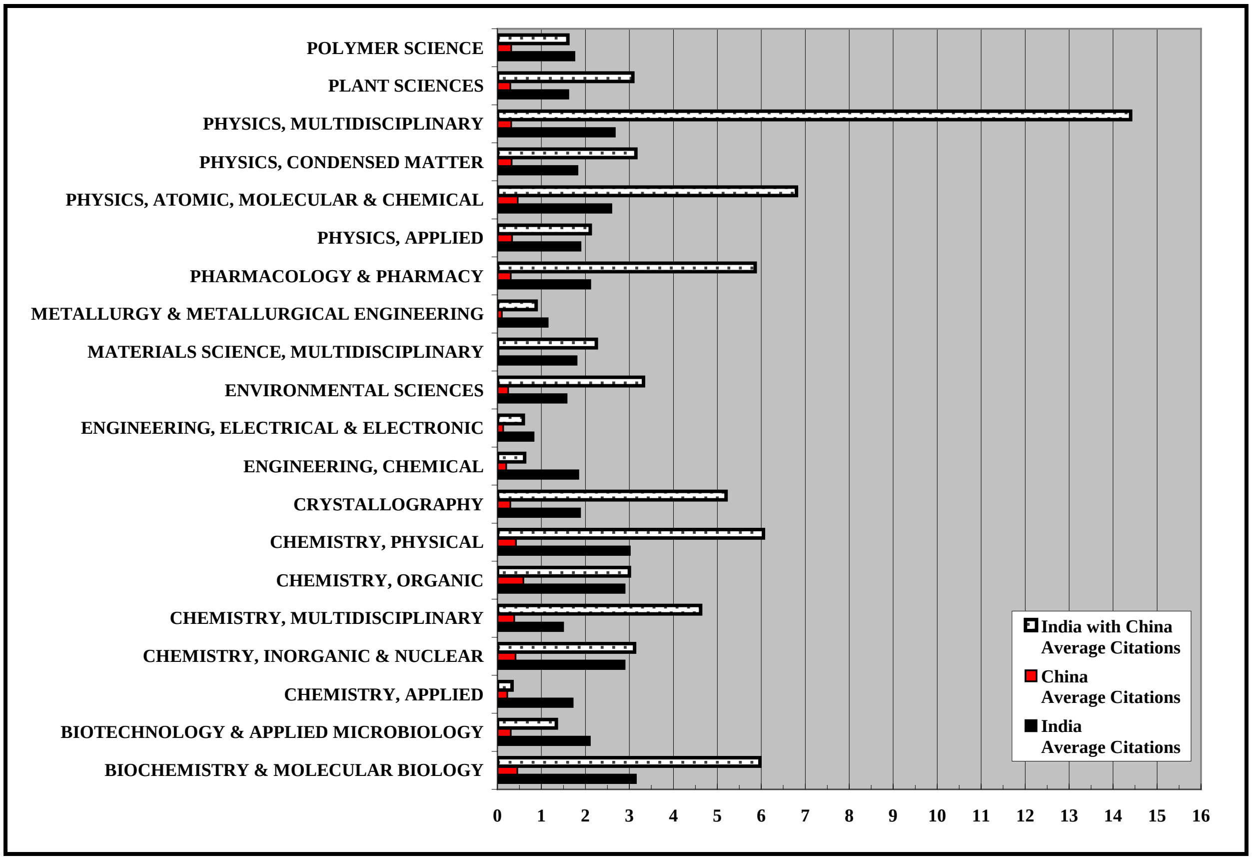

Figure 96. Comparative Category Average Citation Trends for
India, China, and India with China

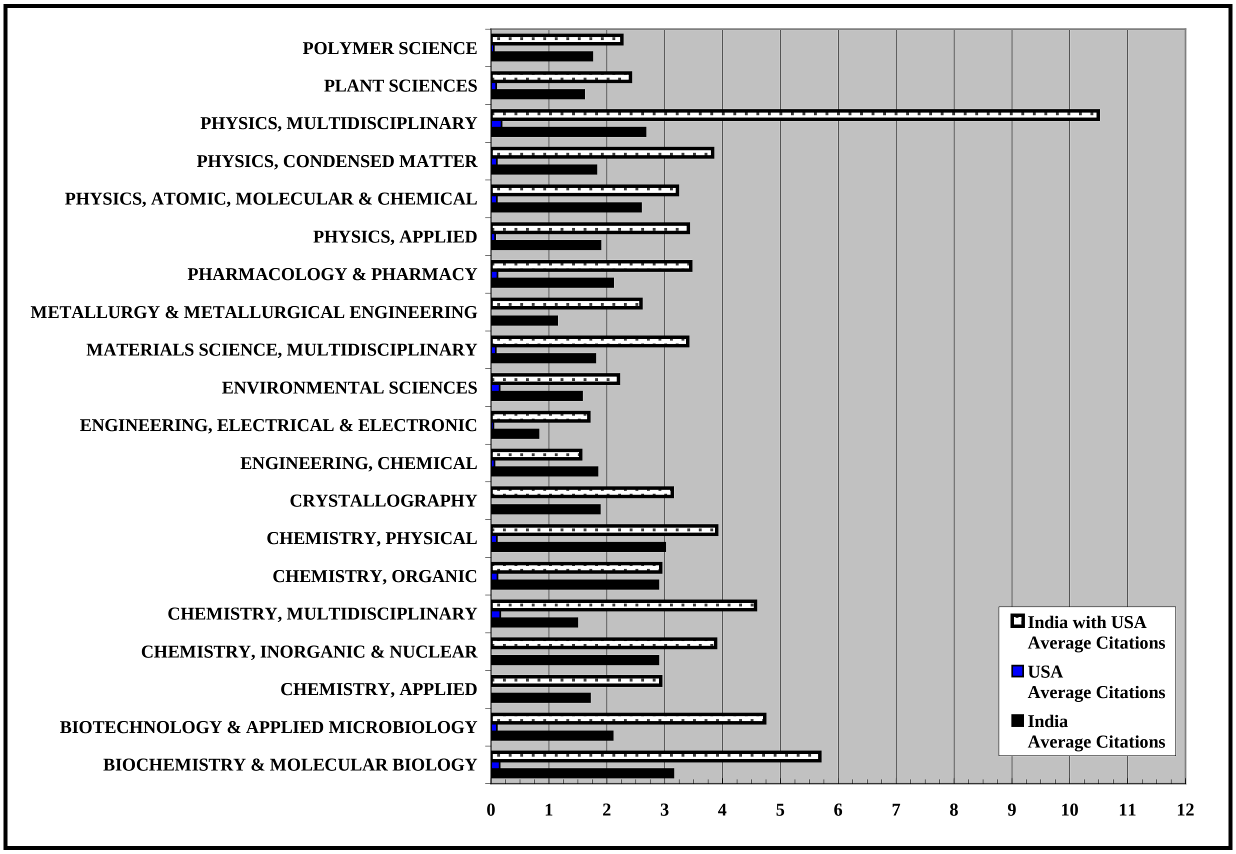

Figure 97. Comparative Category Average Citation Trends for India, USA, and India with USA

- The total number of articles contained within the Top 20 Subject Categories represented a significant percentage (56%) of the total number of articles retrieved. India and China have a similar distribution of total articles between categories with Materials Sciences; Chemistry; Biochemistry and Molecular Biology; and Applied Physics as the predominant categories. USA's only dominant category is Biochemistry and Molecular Biology.

- As a benchmark, there is a clear ranking in the distribution of total citations for all articles; median citation for Top 10 articles; and median citation for Top 10 articles from the Top 10 Journals; between India, China and USA (in order) for all categories.

- However, the trends and rankings in the distribution of the average citation for articles with India (only), India with USA, and India with China addresses have dramatic relative shifts and are completely different. The average citations of articles reflecting bilateral collaboration with USA or China significantly exceed the average citations of indigenous output containing only India addresses.

- There are also no clearly defined relative trends as the average citations fluctuate throughout all categories. The fluctuations are probably not random however, and are likely based on the nature of published research that is specific to each subject category. The nature of publication in this case concerns cumulative article citation rates and journal impact factors that in general cannot be compared across technical disciplines such as applied physics and plant sciences.

- In conclusion, the extended India research collaboration analysis for subject categories indicates the effects of collaboration on regarded utility are evident across a generalized taxonomy of India research, based on assigned Top 20 subject categories, as opposed to the single-technology level (e.g., solid thin films and crops/soils).

Finally, article publication and citation bibliometrics should only be viewed as measures of output and productivity. These metrics are not direct measures of research quality, although there is some threshold quality level inferred, since (in the present study) these papers are published in the (typically) high caliber journals accessed by the SCI/ SSCI, EC and INSPEC databases.

- Journal impact factors are not true or dependable measures of journal quality. Article citation rates determine the Journal impact factor and the number of citations to articles in a specific journal do not directly measure the true quality of the journal or the scientific/technical merit of the contained articles.

- Although the utility of journal impact factors is appropriate for some fields of research such as Applied Physics, and Biochemistry and Molecular Biology, they may not appropriate for use in subject categories that exhibit slower publication patterns, such as plant and environmental sciences. Therefore, the absolute value of an impact factor is meaningless, and the comparison of impact factors across the different fields of research or subject categories is invalid.

- The utility of journal impact factors in bibliometric analyses must also account for the difference in article citation rates. JCR statistics indicate articles in the most cited half of articles in a specific Journal are cited 10 times as often as the least cited half).

- Conclusively, the only viable methodology to assess the quality of research is peer article review. Unfortunately, current peer review practice usually results in article reviews being performed by committees with general competence, as opposed to subject experts.

6.3 Research Expenditure / Output Comparison

The final analysis of the India S&T literature assessment examined the relation between the (2005-2006) budget allocations for each India S&T Department/Ministry and the total combined categorized output from all databases.

- The India Union Budget for the period (2005-2006) includes allocations and descriptions of research being conducted by the primary S&T Departments/Ministries. As indicated in Table 3, the total budget allocation is approximately 17,964 crore rupees or equivalently, $ 3.6 Billion US dollars, with the majority being allocated under the Ministry of Agriculture. It should be noted that the budget allocation percentages for certain S&T Departments/Ministries could be "corrected" to account for expenditures not related to, or resulting in output of published research literature (Ref: 17).

- Total categorized output comprised all combined research articles from each set of SCI/SSCI, EC and INSPEC Level 4 clusters (research focus areas) identified from taxonomy analyses (Table 8). Aggregate focus areas (category headings) for all database taxonomies were used to produce research output categories for classification under the eight S&T Department/Ministry research expenditure areas.

- Using the ratio for the Department of Science and Technology (S&T) as a benchmark, the ratio of budget allocation percentage (9.11%) to the percentage of research articles assigned (51.88%) equaled (0.18). The "corrected" ratio for the Department of Space equals 0.29, when only space sciences are considered, approximates the ratio for S&T (0.18). The "corrected" ratio for Agricultural Research equals 1.90. Lastly, the "corrected" ratio for the Department of Atomic Energy (DAE) equals 1.57.

- The subjective nature of the budget allocation / publication analysis is noted; and while different assignments of the sixteen output categories for each database to the eight expenditure areas are certainly possible, nevertheless, the relative imbalances are probably realistic.

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APPENDIX A

INDIA SCIENCE AND TECHOLOGY (S&T) SYSTEM

ORGANIZATIONAL STRUCTURE OF THE S&T SYSTEM IN INDIA

As described in the main body of this report (Section 1), the Central government S&T departments/agencies are the main instruments for providing resources, defining priorities, and are responsible for attainments of targets in S&T in different sectors. The main functions of these agencies are to support and coordinate research in their respective areas. This is carried out through a chain of laboratories/research institutions under them as well as through research grants/sponsored projects to higher education sector, national laboratories and establishments. The following paragraphs provide brief descriptions of the programs and policies of the six (6) Central government S&T departments/agencies, including listing of associated institutions.

1. Programs and Policies of Primary S&T Departments/Agencies

Department of Space (DOS)

The primary thrust of the **Department of Space (DOS)** is focused towards building state-of-the art satellite systems, launch vehicles and associated ground segment configured for application related to the management of land and ocean resources, satellite communication and meteorology. DOS operates the Indian Space Research Organization (ISRO) and sponsors four independent projects: (1) Indian National Satellite Space Segment Project, (2) Natural Resource Management System, (3) National Remote Sensing Agency, and (4) Physical Research Laboratory. The major achievements of the space program have been in the area of the domestic design, production, and launching of remote sensing and communications satellites. The primary goal of the space program is to have independent remote sensing and communications satellite systems with launcher autonomy. DOS sponsors primary research in eight autonomous institutes, laboratories and research centers as listed in Table A-1.

Table A-1: DOS - Institutes, Laboratories and Research Centers (8)
National Institute of Advanced Studies
Tata Institute of Fundamental Research
Defense Research and Development Laboratory
Physical Research Laboratory, Space and Atmospheric Sciences Division
University of Pune, Department of Atmospheric and Space Sciences
Indian Institute of Technology

Department of Atomic Energy (DAE)

The primary thrust of the Department of Atomic Energy (DAE) is to pursue R&D activities related to nuclear energy and its application. The nuclear power program involves a long-term strategy for exploiting the vast reserves of thorium in the country. The department in a phased manner has been developing reactors that have higher performance standards and are capable of using thorium as nuclear fuel. Spin off technologies covering applications in health care, agriculture, food preservation, industry and research has been successfully developed and transferred to industry. The important mission mode programs are related to the development of technology for utilization of thorium, water desalination, nuclear medicine, and application of irradiation technology for farm products. DAE sponsors research in 16 autonomous institutes, laboratories and research centers as listed in Table A-2.

Table A-2: DAE Institutes, Laboratories and Research Centers (16)
1. Atomic Minerals Directorate for Exploration and Research
2. Bhabha Atomic Research Center
3. Indira Gandhi Center for Atomic Research
4. Raja Ramanna Center for Advanced Technology
5. Variable Energy Cyclotron Center
6. Tata Institute of Fundamental Research
7. Saha Institute of Nuclear Physics
8. Tata Memorial Center
9. Harish-Chandra Research Institute
10. Institute of Physics
11. Institute of Mathematical Sciences
12. Institute of Plasma Research
13. Atomic Energy Education Society
14. Board of Research in Nuclear Sciences (BRNS)
15. National Board for higher Mathematics (NBHM)
16. Homi Bhabha National Institute

Department of Biotechnology (DBT)

The primary thrust of the Department of Biotechnology (DBT) sponsors various programs and R&D projects in many different areas of biotechnology. Some of the primary research areas include: (1) Agriculture, (2) Plant Biotechnology, (3) Medical Biotechnology, (4) Human Genetics and Genome Analysis, (5) Seri Biotechnology, (6) Stem Cell, (7) Food Biotechnology, and (8) Environmental Biotechnology. DBT sponsors research in seven autonomous institutes, laboratories and research centers as listed in Table A-3.

Table A-3: DBT Institutes, Laboratories and Research Centers (7)
1. Centre For DNA Fingerprinting And Diagnostics (CDFD), Hyderabad
2. Institute of Life Sciences, Bhuvaneswar
3. Institute of Bioresources and Sustainable Development (IBSD), Imphal
4. National Institute Of Immunology, New Delhi
5. National Centre For Plant Genome Research (NCPGR), New Delhi
6. National Brain Research Centre (NBRC), Gurgaon
7. National Centre for Cell Sciences, Pune

To promote public-private partnership, the Department of Biotechnology (DBT) promoted the Biotech Consortium of India Limited (BCIL) in 1990 with a core capital of Rs. 5.37 crore. The contributors to this fund include financial institutions, public and private limited companies and venture capital funding. The BCIL has a membership of 232 industries and R&D institutions.

Department of Science and Technology (DST)

The primary thrusts of DST programs cover the following domains: Scientific research support to different scientific disciplines, International scientific cooperation, Societal programs, Infrastructure development program, Technology Development, S&T Manpower Development and Promotion, S&T for Women, Management Information System, Meteorology mapping and survey, support to scientific/engineering academies. The Department has set up Sophisticated Analytical Instrument Facilities (SAIFs) in different parts of the country to provide the facilities of sophisticated analytical instruments to the research workers in general and especially from the institutions, which do not have access to such instruments to enable them to pursue R&D activities. At present, 13 Sophisticated Analytical Instrument Facilities (SAIFs) have been created in selected universities and research institutes across the country covering different disciplines (2003-04 Annual Report DST). "FIST - Fund for improvement of S&T infrastructure" in universities and higher educational institutions scheme was launched by DST in 2000-2001. Under this scheme, financial supports have been provided to various university departments and colleges for creating basic infrastructure and enabling facilities for promoting high quality teaching and R&D in new and emerging areas. Apart from the above two programs, DST has a number of other programs for strengthening the R&D activity in the country. It has specialized programs for drug research and development, in advanced materials (mainly in nanomaterials), climate studies, etc. DST sponsors research in seventeen (17) autonomous institutes, laboratories and research centers as listed in Table A-4.

Table A-4: DST Institutes, Laboratories and Research Centers (17)
1. Agharkar Research Institute, Pune
2. Aryabhatta Research Institute of Observational-Sciences, Nainital
3. Birbal Sahni Institute of Palaeobotany, Lucknow
4. Bose Institute, Kolkata
5. Center for Liquid Crystal Research, Jalahalli, Bangalore
6. Indian Association for the Cultivation of Science, Kolkata
7. International Advanced Research Center, Powder Metallurgy and New Materials, Hyderabad
8. Indian Institute of Astrophysics, Bangalore
9. Indian Institute of Geomagnetism, Mumbai
10. Jawaharlal Nehru Center for Advanced Scientific Research, Bangalore
11. National Accreditation Board for Testing & Calibration Laboratories, New Delhi
12. Raman Research Institute, Bangalore
13. S.N. Bose National Center for Basic Sciences, Kolkata
14. Sreechitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram
15. Technology Information, Forecasting & Assessment Council (TIFAC), New Delhi
16. Vigyan Prasar, New Delhi
17. Wadia Institute of Himalayan Geology, Dehradun

Department of Scientific and Industrial Research (DSIR) including Council of Scientific and Industrial Research (CSIR)

The plans and programs relating to scientific and industrial research are implemented by the DSIR and CSIR. The DSIR is concerned with the promotion of industrial R&D, development of new technologies and processes, acquisition, management and export of technology and development of consultancy capabilities. DSIR has an ongoing program for recognition of in-house R&D centers of industrial entities. The recognized centers can avail fiscal and non-fiscal incentives for further development of R&D. Transfer of technology from research institutes, facilitating patenting activity, providing startup capital for commercialization of indigenous technologies and other related activities are taken up by NRDC (National Research and Development Corporation), autonomous institute under DSIR. CEL (Central Electronics Limited) another autonomous institute under DSIR is involved in developing communication devices, solar cells, etc. CSIR's mission is to provide scientific industrial R&D to maximize economic, environmental and social benefits. CSIR has generated number of technologies mainly through in-house R&D work. CSIR is providing a platform for Indian industry in their foray in developing leading edge technology. CSIR is making vigorous efforts to patent its technologies. New Millennium Technology Leadership (NIMITLI) has been initiated by CSIR to bring different actors in the innovation chain (R&D organizations, universities, private industry) in a common platform for joint technology development. DSIR sponsors research in thirty-nine (39) autonomous institutes, laboratories and research centers as listed in Table A-5.

Table A-5: DSIR/CSIR Institutes, Laboratories and Research Centers (39)
1. Center for Mathematical Modeling and Computer Simulation, Bangalore (C-MMACS)
2. Central Building Research Institute (CBRI), Roorkee
3. Center for Cellular and Molecular Biology (CCMB), Hyderabad
4. Central Drug Research Institute (CDRI), Lucknow
5. Central Electro Chemical Research Institute (CECRI), Karaikudi
6. Central Electronics Engineering Research Institute (CEERI), Pilani
7. Central Fuel Research Institute (CFRI), Dhanbad
8. Central Food Technological Research Institute (CFTRI), Mysore
9. Central Glass and Ceramic research Institute (CGCRI), Calcutta
10. Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow
11. Central Leather Research Institute (CLRI), Chennai
12. Central Mechanical Engineering Research Institute (CMERI), Durgapur
13. Central Mining Research Institute (CMRI), Dhanbad
14. Central Road Research Institute (CRRI), New Delhi
15. Central Scientific Instruments Organization (CSIO), Chandigarh
16. Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar
17. Institute of Genomics and Integrative Biology (IGIB), Delhi
18. Institute of Himalayan Bioresource Technology (IHBT), Palampur
19. Indian Institute of Chemical Biology (IICB), Calcutta
20. Indian Institute of Chemical Technology (IICT), Hyderabad
21. Indian Institute of Petroleum (IIP), Dehradun
22. Institute of Microbial Technology (IMT), Chandigarh
23. Industrial Toxicology Research Center (ITRC), Lucknow
24. National Aerospace Laboratories (NAL), Bangalore
25. National Botanical Research Institute (NBRI), Lucknow

Table A-5: DSIR/CSIR Institutes, Laboratories and Research Centers (39)
26. National Chemical Laboratory (NCL), Pune
27. National Environmental Engineering Research Institute (NEERI), Nagpur
28. National Geophysical Research Institute (NGRI), Hyderabad
29. National Institute of Oceanography (NIO), Goa
30. National Institute of Science Communication and Information Resources (NISCAIR), New Delhi
31. National Institute of Science, Technology and Development Studies (NISTADS), New Delhi
32. National Metallurgical Laboratory (NML), Jamshedpur
33. National Physical Laboratory (NPL), New Delhi
34. Regional Research Laboratory (RRL), Bhopal
35. Regional Research Laboratory (RRL), Bhubaneshwar
36. Regional Research Laboratory (RRL), Jammu
37. Regional Research Laboratory (RRL), Jorhat
38. Regional Research Laboratory (RRL), Thiruvananthapuram
39. Structural Engineering Research Center (SERC), Chennai

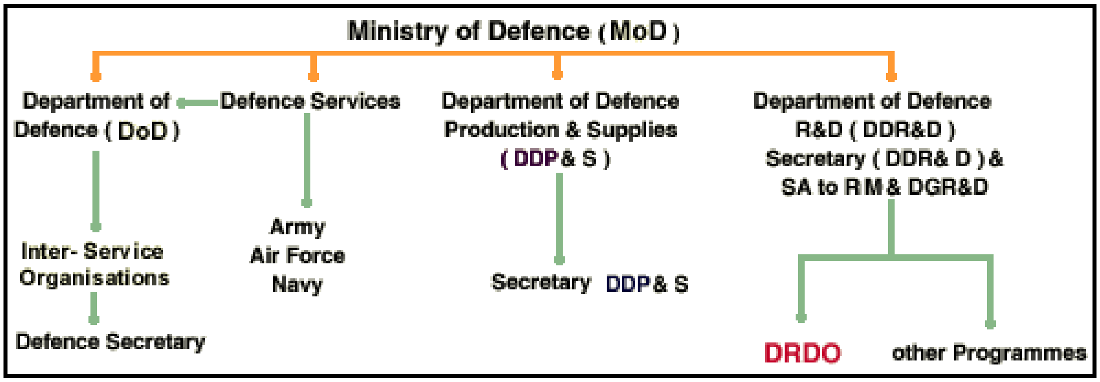
Department of Ocean Development (DOD)

The primary thrusts of DOD programs cover the following domains: Basic marine research, Polar (Antarctic) science, Marine living and non-living resources, Marine and coastal area management, Deep seabed exploration, Ocean observation and information, and Ocean awareness. DOD sponsors research in several primary research institutes, laboratories and research centers as listed in Table A-6

Table A-6: DOD Institutes, Laboratories and Research Centers (15)
1. Center for Marine Living Resources (CMLRE)
2. India Center for Marine Area Management (ICMAM)
3. India Meteorological Department (IMD)
4. Indian Institute of Science (IISc)
5. Indian Institute of Tropical Meteorology (IITM)
6. Indian Institute of Technology, Madras, (IITM)
7. Indian National Center for Ocean Information Services (INCOIS)
8. Institute of Ocean Management (IOM), Anna University, Chennai
9. National Center for Antarctic & Ocean Research (NCAOR)
10. National Center for Medium Range Weather Forecasting (NCMRWF)
11. National Institute of Oceanography (NIO)
12. National Institute of Ocean Technology (NIOT)
13. National Geophysical Research Institute (NGRI)
14. Physical Research Laboratory
15. Banaras Hindu University

Defense Research and Development Organization (DRDO)

DRDO functions as wing of the Department of Defense Research and Development (DD R&D) as shown below.



The primary mission of DRDO is to: (1) Design, develop and lead to production state-of-the-art sensors, weapon systems, platforms and allied equipment, (2) Provide technological solutions to optimize combat effectiveness and to promote well-being of troops, and (3) Develop infrastructure and committed quality manpower and build strong indigenous technology base. Table A-7 provides a listing of the principal DRDO laboratories (Ref: 11). DRDO also sponsors basic research in numerous academic institutions in a broad spectrum of domains including extramural research, aeronautics, naval research, life sciences, and armaments.

Table A-7: Defense Research and Development Organization (DRDO) Laboratories (50)
Aeronautics
1. Aeronautical Development Establishment (ADE), Bangalore
2. Aerial Delivery Research & Development Establishment (ADRDE), Agra
3. Centre for Air Borne Systems (CABS), Bangalore
4. Defense Avionics Research Establishment (DARE), Bangalore
5. Gas Turbine Research Establishment (GTRE), Bangalore
6. Center for Military Airworthiness & Certification (CEMILAC), Bangalore
Armaments
7. Armament Research & Development Establishment (ARDE), Pune
8. Centre for Fire, Explosive & Environment Safety (CFEES), Delhi
9. High Energy Materials Research Laboratory (HEMRL), Pune
10. Proof & Experimental Establishment (PXE), Balasore
11. Terminal Ballistics Research Laboratory(TBRL),Chandigarh
Combat Vehicles & Engineering
12. Combat Vehicles Research & Development Establishment (CVRDE), Chennai
13. Vehicle Research & Development Establishment (VRDE), Ahmednagar
14. Research & Development Establishment (R&DE), Pune
15. Snow & Avalanche Study (SASE), Chandigarh

Table A-7: Defense Research and Development Organization (DRDO) Laboratories (50)
Electronics & Computer Sciences
16. Advanced Numerical Research & Analysis Group (ANURAG), Hyderabad
17. Center for Artificial Intelligence & Robotics (CAIR), Bangalore
18. DRONA CELL, Delhi
19. Defense Electronics Application Laboratory (DEAL), Dehradun
20. Defense Electronics Research Laboratory (DLRL), Hyderabad
21. Defense Terrain Research Laboratory (DTRL), Delhi
22. Defense Scientific Information & Documentation Centre (DESIDOC), Delhi
23. Instruments Research & Development Establishment (IRDE), Dehradun
24. Laser Science & Technology Centre (LASTEC), Delhi
25. Electronics & Radar Development Establishment (LRDE), Bangalore
26. Microwave Tube Research & Development Center (MTRDC), Bangalore
27. Solid State Physics Laboratory (SSPL), Delhi
28. Scientific Analysis Group (SAG), Delhi
Human Resource Development
29. Defense Institute of Advanced Technology (Deemed University), Pune
30. Institute of Technology Management (ITM), Mussorie
Life Sciences
31. Defense Agricultural Research Laboratory (DARL), Pithoragarh
32. Defense Bio-Engineering & Electro Medical Laboratory (DEBEL), Bangalore
33. Defense Food Research Laboratory (DFRL), Mysore
34. Defense Institute of Physiology & Allied Sciences (DIPAS), Delhi
35. Defense Institute of Psychological Research (DIPR), Delhi
36. Defense Research Laboratory (DRL), Tejpur
37. Field Research Laboratory (FRL)
38. Institute of Nuclear Medicine & Allied Sciences (INMAS), Delhi
39. Defense Research & Development Establishment (DRDE), Gwalior
Materials
40. Defense Laboratory (DLJ), Jodhpur
41. Defense Metallurgical Research Laboratory (DMRL), Hyderabad
42. Defense Materials & Stores Research & Development Establishment (DMSRDE), Kanpur
Missiles
43. Defense Research & Development Laboratory (DRDL), Hyderabad
44. Institute of Systems Studies & Analyses (ISSA), Delhi
45. Integrated Test Range (ITR), Balasore
46. Research Center Imarat (RCI), Hyderabad
Naval Research & Development
47. Naval Materials Research Laboratory (NMRL), Ambernath
48. Naval Physical & Oceanographic Laboratory (NPOL), Cochin
49. Naval Science & Technological Laboratory (NSTL), Vishakapatnam
Technologies
50. G-FAST, Delhi

Indian Institutes of Technology (IITs)

The Indian S&T system also comprise the Indian Institutes of Technology (IITs) that are autonomous engineering and technology oriented institutes of higher education established and declared as Institutes of National Importance by the Government of India. Currently, there are seven (7) IITs as listed below in Table A-8. Several IITs were established with financial assistance and technical expertise from UNESCO, Germany, the United States, and Russia, and there are current plans to establish three additional IITs in Rajasthan, Bihar and Andhra Pradesh, increasing the total number to ten (10). The success of these IITs has led to establishment of similar institutes performing research in other fields, including the National Institutes of Technology, the Indian Institutes of Management and the Institutes of Information Technology (IIIT) (Ref. 5).

Table A-8: Indian Institutes of Technology (7)
1. Indian Institute of Technology, Bombay
2. Indian Institute of Technology, Delhi
3. Indian Institute of Technology, Guwahati
4. Indian Institute of Technology, Kanpur
5. Indian Institute of Technology, Kharagpur
6. Indian Institute of Technology, Madras
7. Indian Institute of Technology, Roorkee

National Institutes of Technology (NITs)

National Institutes of Technology (NITs) are premier colleges of engineering and technology education in India. They were originally called as Regional Engineering Colleges (RECs). In 2002, the Union Ministry of Human Resource Development, Government of India, decided to upgrade, in phases, all the original 17 Regional Engineering Colleges (RECs) as National Institutes of Technology (NITs), on the lines of the prestigious Indian Institutes of Technology (IITs). These institutes are rated just next to the IITs in terms of student quality, research and placements. There are currently 20 NIT's, the latest being NIT, Agartala, as listed below in Table A-9. Their locations are deliberately scattered throughout in every major state of India for regional development. The individual NITs after the introduction of the NIT Act will function as autonomous universities and draft their own curriculum and functioning policies (Ref. 6).

Table A-9: National Institutes of Technology (20)
1. National Institute of Technology, Agartala
2. Motilal Nehru National Institute of Technology, Allahabad
3. Maulana Azad National Institute of Technology, Bhopal
4. National Institute of Technology, Calicut
5. National Institute of Technology, Durgapur
6. National Institute of Technology, Hamirpur
7. Malaviya National Institute of Technology, Jaipur
8. Dr B R Ambedkar National Institute of Technology, Jalandhar
9. National Institute of Technology, Jamshedpur

Table A-9: National Institutes of Technology (20)
10. National Institute of Technology, Kurukshetra
11. Visvesvaraya National Institute of Technology, Nagpur
12. National Institute of Technology, Patna
13. National Institute of Technology, Raipur
14. National Institute of Technology, Rourkela
15. National Institute of Technology, Silchar
16. National Institute of Technology, Srinagar
17. National Institute of Technology Karnataka, Surathkal
18. National Institute of Technology, Tiruchirapalli
19. National Institute of Technology, Warangal
20. Sardar Vallabhbhai National Institute of Technology, Surat

APPENDIX B

PARTITIONAL CLUSTERING METHOD

CLUTO [Karypis, 2004] is a software package that implements various algorithms for clustering low- and high-dimensional datasets and for analyzing the characteristics of the various clusters. CLUTO implements three different classes of clustering algorithms that can operate either directly in the object's feature space or in the object's similarity space. The clustering algorithms provided by CLUTO are based on the partitional, agglomerative, and graph-partitioning paradigms. CLUTO's partitional and agglomerative algorithms are able to find clusters that are primarily globular, whereas it's graph partitioning and some of its agglomerative algorithms are capable of finding transitive clusters. In this study, documents were clustered using the partitional clustering algorithms provided by CLUTO. Partitional clustering algorithms find the clusters by partitioning the entire document collection into a predetermined number of disjoint sets, each corresponding to a single cluster. This partitioning is achieved by treating the clustering process as an optimization procedure that tries to create high quality clusters according to a particular function that reflects the underlying definition of the "goodness" of the clusters. This function is referred to as the *clustering criterion function.* CLUTO implements seven such criterion functions that measure various aspects of intra-cluster similarity, inter-cluster dissimilarity, and their combinations, and have been shown to produce high-quality clusters in low- and high-dimensional datasets [Zhao and Karypis, 2004].

CLUTO uses two different methods for computing the partitioning clustering solution. The first method computes a *k*-way clustering solution via a sequence of repeated bisections, whereas the second method computes the solution directly (in a fashion similar to traditional *K*-means-based algorithms). These methods are often referred to as *repeated bisecting* and *direct k*-way clustering, respectively. CLUTO computes a direct *k*-way clustering as follows. Initially, a set of *k* objects is selected from the datasets to act as the *seeds* of the *k* clusters. Then, for each object, its similarity to these *k* seeds is computed, and it is assigned to the cluster corresponding to its most similar seed. This forms the initial *k*-way clustering. This clustering is then repeatedly refined so that it optimizes a desired clustering criterion function. This optimization is performed using a randomized incremental optimization algorithm that is greedy in nature, has low computational requirements, and produces high-quality solutions [Zhao and Karypis, 2004]. A *k*-way partitioning via repeated bisections is obtained by recursively applying the above algorithm to compute 2-way clustering (*i.e.*, bisections). Initially, the objects are partitioned into two clusters, and then one of these clusters is selected and is further bisected, and so on. This process continues *k* - 1 times, leading to *k* clusters. Each of these bisections is performed so that the resulting two-way clustering solution optimizes a particular criterion function. The actual documents were represented with the widely used vector-space model. The various terms present in the documents were used to define a high-dimensional space and each document was considered a vector in that space. However, unlike the traditional vector-space representation, which relies entirely on single terms, all consecutive two- and three-word combinations were taken into account, resulting in a representation that is capable of capturing the phrases commonly occurring in the documents. In addition, Porter's stemming algorithm was used to pre-process the various terms of each document prior to obtaining their vector-space representation. The weight of each dimension was computed using the TF-IDF model in which terms that occur many times within a document are given higher weight (TF) and terms that occur across many documents were given lower weight (IDF) [Zhao and Karypis, 2004]. The similarity between two documents was measured using the cosine of their corresponding document vectors.

APPENDIX C

SCI/SSCI DATABASE TAXONOMIES
(2005-2006)

Taxonomy Diagram and Node Details

SCI/SSCI Taxonomy (2005-2006)

SCI/SSCI (2005-2006) Hierarchical Taxonomy (Levels 0 - 4)

Level 0	Level 1	Level 2	Level 3	Level 4
				Cluster {358} - 578 records clinical medicine neurology and neuroscience surgery / pathology
				Cluster {276} - 204 records clinical medicine human patient diseases pathology / oncology
				Cluster {405} - 839 records clinical medicine neurology and neuroscience neurosurgery
				Cluster {339} - 1,204 records clinical medicine human patient diseases pathology
			Cluster {385} - 782 records biomedical research clinical medicine neurology and neuroscience	Cluster {495} - 4,225 records environmental sciences plant sciences / geology / plant biochemistry and biotechnology
		Cluster {470} - 2,825 records biomedical research	Cluster {439} - 2,043 records biomedical research clinical medicine human patient diseases	Cluster {489} - 3,316 records molecular and cellular biochemistry microbiology and biotechnology plant sciences / plant biochemistry and biotechnology
Cluster {510} - 46,819 records PHYSICAL SCIENCES LIFE SCIENCES EARTH SCIENCES MATHEMATICS	Cluster {507} - 16,152 records LIFE SCIENCES EARTH SCIENCES	Cluster {505} - 13,327 records veterinary and animal sciences biology and biochemistry food and agricultural sciences	Cluster {503} - 7,541 records biology and biochemistry food and agricultural sciences molecular and cellular biochemistry microbiology and biotechnology	Cluster {462} - 1,951 records molecular and cellular biochemistry microbiology and biotechnology plant sciences / toxicology and pharmacology
	Cluster {509} - 30,667 records PHYSICAL SCIENCES MATHEMATICS	Cluster {508} - 22,114 records chemistry physics materials science and engineering	Cluster {500} - 5,786 records food and agricultural sciences veterinary and animal sciences molecular and cellular biochemistry	Cluster {494} - 3,835 records microbiology and biotechnology environmental biology / plant sciences / agronomy
		Cluster {506} - 8,553 records chemistry physics materials science and engineering	Cluster {502} - 11,563 records physics scientific and industrial research astronomy and astrophysics nuclear and particle physics	Cluster {484} - 3,719 records scientific and industrial research pattern recognition and machine intelligence
			Cluster {504} - 10,551 records chemistry materials science and engineering physical chemistry thin solid films	Cluster {497} - 7,844 records astronomy and astrophysics nuclear and particle physics plasma physics / high energy physics
			Cluster {501} - 4,097 records chemistry physical chemistry molecular and cellular biochemistry	Cluster {499} - 4,806 records thin solid films crystal growth research and technology nanoscience and nanotechnology
			Cluster {493} - 4,456 records chemistry physical chemistry molecular and cellular biochemistry	Cluster {498} - 5,745 records physical chemistry hazardous materials / colloid and interface science membrane separation and purification technology
				Cluster {496} - 3,613 records physical chemistry molecular liquids / nano-metal chemistry colloid and interface science
				Cluster {0} - 484 records inorganic chemistry physical chemistry crystal growth research and technology / crystallography
				Cluster {445} - 1,926 records molecular and cellular biochemistry organic and biomolecular chemistry pharmaceutical research
				Cluster {481} - 2,530 records physical chemistry molecular and cellular biochemistry molecular synthesis and catalysis / chemical science and kinetics

SCI/SSCI Level 1

Level 1 is divided into two clusters with the following primary and secondary category headings:

Cluster {507} - 16,152 records

Primary: LIFE SCIENCES and EARTH SCIENCES
Secondary: Life Sciences are focused on biology and biochemistry, biomedical research, veterinary and animal sciences, food and agricultural sciences. Earth Sciences are focused on marine science.
SCI/SSCI Level 1: Cluster 507 (16,152 Records)
(**Themes:** patient 5.0%, cell 2.5%, protein 1.6%, level 1.5%, activ 1.4%, gene 1.2%, plant 1.1%, treatment 1.1%, extract 0.9%, isol 0.9%, speci 0.9%, enzym 0.8%, control 0.8%, diseas 0.7%, soil 0.7%, rat 0.7%, induc 0.7%, infect 0.7%, acid 0.7%, (24.38%)).
(**Keywords:** india 899, growth 552, expression 509, oxidative stress 486, identification 407, lipid-peroxidation 394, cells 373, disease 332, protein 318, children 295, management 288, cancer 282, purification 274, in-vitro 272, infection 270, plants 262, apoptosis 262, inhibition 257, acid 256, gene 250, diagnosis 249, lipid peroxidation 248, glutathione 248, dna 248, rats 247, mice 247, toxicity 246, proteins 243, metabolism 243, induction 214).

Cluster {509} - 30,667 records

Primary: PHYSICAL SCIENCES and MATHEMATICS
Secondary: Physical Sciences are focused on chemistry, physics, and materials science and engineering. Mathematics is focused on applied mathematics and computation science.
SCI/SSCI Level 1: Cluster 509 (30,667 Records)
(**Themes:** temperatur 1.7%, model 1.6%, structur 1.2%, complex 1.2%, reaction 1.1%, system 1.0%, film 1.0%, phase 1.0%, ion 0.8%, compound 0.8%, solut 0.8%, energi 0.8%, paramet 0.7%, acid 0.7%, state 0.7%, electron 0.7%, properti 0.6%, crystal 0.6%, data 0.6%, (18.27%)).
(**Keywords:** derivatives 995, behavior 854, model 788, systems 728, kinetics 709, temperature 628, system 597, oxidation 584, acid 580, water 570, complexes 570, crystal-structure 549, films 493, chemistry 487, adsorption 486, mechanism 454, growth 438, spectroscopy 426, design 411, thin-films 383, stability 381, spectra 376, particles 371, dynamics 364, nanoparticles 355, polymers 337, microstructure 336, transition 319, x-ray diffraction 302, transport 302).

SCI/SSCI Level 4

Level 4 is divided into sixteen (16) clusters. They are described in order of their listing in Table 22, starting from the top with the following tertiary category headings and single technology focus areas:

Cluster {358}

Tertiary: Clinical Medicine, Neurology and Neuroscience cover surgery and pathology with focus on dermatology, radiology and oral medicine.

SCI/SSCI Level 4: Cluster 358 (578 Records)

(**Themes:** lesion 8.7%, case 6.7%, old 5.4%, rare 4.9%, diagnosi 2.9%, patient 2.2%, syndrom 1.9%, bone 1.5%, surgic 1.3%, cyst 1.3%, clinic 1.2%, diseas 1.1%, imag 1.1%, congenit 1.0%, child 1.0%, fistula 0.8%, abscess 0.8%, nerv 0.8%, mri 0.8%, (46.46%)).

(**Keywords:** diagnosis 35, children 32, management 28, disease 23, mri 22, ct 14, tumors 12, surgery 12, india 12, magnetic resonance imaging 11, experience 10, ultrasound 9, brain 9, tuberculosis 8, therapy 8, spinal-cord 8, patient 8, lesions 8, complications 8, spectrum 7, resection 7, features 7, child 7, abscess 7, spectroscopy 6, repair 6, laparoscopy 6, involvement 6, histopathology 6, childhood 6).

SCI/SSCI Level 4: Cluster 358 Bibliometrics

(**Author Affiliations:** all india inst med sci 76, postgrad inst med educ & res 36, sanjay gandhi postgrad inst med sci 32, christian med coll & hosp 25, maulana azad med coll 20, univ coll med sci 12, kasturba med coll & hosp 12, univ delhi 11, sree chitra tirunal inst med sci & technol 9, king georges med univ 9, sir ganga ram hosp 8, lady hardinge med coll & hosp 7, govt med coll 7, seth gs med coll 6, safdarjang hosp 6, pt bd sharma pgims 6, pgimer 6, manipal coll dent sci 6, king edward mem hosp 6, guru teg bahadur hosp 6, tata mem hosp 5, st stephens hosp 5, natl inst mental hlth & neurosci 5, jawaharlal inst postgrad med educ & res 5, indian vet res inst 5).

(**Authors:** sharma, a 12, mahapatra, ak 12, sharma, mc 11, sarkar, c 11, kumar, s 11, gupta, a 10, gupta, v 9, sharma, s 8, sharma, r 8, sethi, a 8).

(**Sources:** indian pediatrics 29, indian veterinary journal 27, neurology india 26, pediatric surgery international 19, journal of clinical neuroscience 15, pediatric radiology 12, journal of laryngology and otology 11, international journal of dermatology 11, journal of pediatric surgery 9, childs nervous system 9, journal of endourology 8, international journal of pediatric otorhinolaryngology 8, indian journal of animal sciences 8, british journal of neurosurgery 8, tropical doctor 7, surgical neurology 7, pediatric neurosurgery 7, surgical laparoscopy endoscopy & percutaneous techniques 6, leprosy review 6, journal of ultrasound in medicine 6, journal of tropical pediatrics 6, skeletal radiology 5, rivista di neuroradiologia 5, journal of dermatology 5, international surgery 5).

(**Author Country**: india 577, united states 25, united kingdom 10, germany 7, singapore 4, netherlands 4, canada 3, australia 3, thailand 2, sweden 2, belgium 1).

Cluster {276}

Tertiary: Clinical Medicine and Human Patient Diseases cover pathology and oncology with focus on cytology and cytopathology.

SCI/SSCI Level 4: Cluster 276 (204 Records)

(**Themes:** tumor 18.4%, cytolog 5.2%, diagnosi 3.9%, malign 2.9%, aspir 2.5%, carcinoma 2.1%, tumour 1.8%, smear 1.8%, tissu 1.7%, fnac 1.6%, case 1.5%, rare 1.5%, stain 1.4%, fine.needle 1.3%, benign 1.3%, patient 1.3%, lesion 1.2%, needl 1.2%, breast 1.2%, (55.12%)).

(**Keywords:** tumors 24, diagnosis 24, carcinoma 24, cancer 15, breast cancer 14, biopsy 14, aspiration biopsy 14, cytology 12, features 10, disease 10, management 9, fine-needle-aspiration 9, fnac 8, children 8, tuberculosis 7, lesions 7, gland 7, fine-needle 7, expression 7, immunohistochemistry 6, prognosis 5, oral cancer 5, metastasis 5, cells 5, uterine cervix 4, tumor 4, therapy 4, squamous-cell carcinoma 4, specimens 4, skull 4)

SCI/SSCI Level 4: Cluster 276 Bibliometrics

(**Author Affiliations:** all india inst med sci 35, tata mem hosp 23, postgrad inst med educ & res 16, sanjay gandhi postgrad inst med sci 9, maulana azad med coll 9, kasturba med coll & hosp 6, banaras hindu univ 5, king georges med univ 4, indian inst technol 4, govt med coll 4, christian med coll & hosp 4, vis res fdn 3, sree chitra tirunal inst med sci & technol 3, safdarjang hosp 3, reg canc ctr 3, jln hosp & res ctr 3, guru teg bahadur hosp 3, univ miami 2, univ coll med sci 2, seth gs med coll & kem hosp 2, seth gs med coll 2, rajiv gandhi canc inst & res ctr 2, punjab agr univ 2, northwestern univ 2, nanavati hosp 2).

(**Authors:** sarkar, c 8, verma, k 6, sharma, mc 6, kumar, r 6, srinivasan, r 5, singh, s 5, rajwanshi, a 5, nijhawan, r 5, kumar, s 5, kumar, p 5).

(**Sources:** acta cytologica 23, diagnostic cytopathology 17, international journal of gynecological cancer 7, journal of surgical oncology 5, analytical and quantitative cytology and histology 5, journal of clinical neuroscience 4, cytopathology 4, rivista di neuroradiologia 3, pediatric neurosurgery 3, pathology & oncology research 3, ophthalmic plastic and reconstructive surgery 3, neurology india 3, international surgery 3, european journal of dermatology 3, clinical and experimental ophthalmology 3, pediatric nephrology 2, pediatric hematology and oncology 2, pathology research and practice 2, journal of pediatric surgery 2, journal of oral pathology & medicine 2, journal of neuro-oncology 2, journal of clinical ultrasound 2, international journal of urology 2, international journal of pediatric otorhinolaryngology 2, international journal of dermatology 2)

(**Author Country:** india 203, united states 12, united kingdom 5, kuwait 2, belgium 2, ukraine 1, turkey 1, poland 1, norway 1, netherlands 1).

Cluster {405}

Tertiary: Clinical Medicine, Neurology and Neuroscience cover surgery with focus on cataract and refractive surgery, thoracic surgery, anesthesia and analgesia, neuroradiology and neurosurgery.

SCI/SSCI Level 4: Cluster 405 (839 Records)

(Themes: patient 31.3%, surgeri 6.1%, ey 3.2%, arteri 2.9%, postop 2.5%, pain 1.5%, complic 1.4%, surgic 1.3%, mean 1.0%, left 0.8%, stent 0.8%, laparoscop 0.7%, right 0.6%, anterior 0.6%, visual 0.6%, oper 0.5%, posterior 0.4%, fractur 0.4%, score 0.4%, (57.38%)).

(**Keywords:** management 88, surgery 64, children 39, complications 36, experience 34, disease 30, diagnosis 25, anesthesia 19, repair 18, pain 18, surgical-treatment 15, laparoscopy

15, follow-up 14, risk 13, trial 12, therapy 11, hypertension 11, embolization 11, artery 11, analgesia 11, stenosis 10, removal 10, penetrating keratoplasty 10, efficacy 10, carcinoma 10, aneurysm 10, trauma 9, risk-factors 9, resection 9, prevention 9).

SCI/SSCI Level 4: Cluster 405 Bibliometrics

(**Author Affiliations**: all india inst med sci 142, sanjay gandhi postgrad inst med sci 59, postgrad inst med educ & res 49, sree chitra tirunal inst med sci & technol 34, christian med coll & hosp 31, lv prasad eye inst 22, kasturba med coll & hosp 18, sir ganga ram hosp 14, tata mem hosp 13, safdarjang hosp 11, banaras hindu univ 11, seth gs med coll 10, gupta nursing home 9, gb pant hosp 9, univ coll med sci 8, natl inst mental hlth & neurosci 8, aravind eye hosp 8, sankara nethralaya 7, nizams inst med sci 7, guru teg bahadur hosp 7, rg stone urol res inst 6, king edward mem hosp 6, kem hosp 6, jawaharlal inst postgrad med educ & res 6, indian inst technol 6).

(**Authors**: kumar, a 34, singh, r 24, gupta, ak 23, purkayastha, s 17, sharma, n 15, agarwal, a 15, kumar, s 14, goel, a 14, vajpayee, rb 13, singh, u 13).

(**Sources:** journal of endourology 22, journal of cataract and refractive surgery 21, annals of thoracic surgery 19, anesthesia and analgesia 19, neurology india 18, american journal of ophthalmology 17, indian veterinary journal 16, clinical and experimental ophthalmology 13, world journal of surgery 12, urology 12, catheterization and cardiovascular interventions 12, anz journal of surgery 11, anaesthesia 11, journal of cardiothoracic and vascular anesthesia 10, graefes archive for clinical and experimental ophthalmology 10, surgical laparoscopy endoscopy & percutaneous techniques 9, journal of neurosurgery 9, canadian journal of anaesthesia-journal canadien d anesthesie 9, annals of ophthalmology 9, urologia internationalis 8, surgical endoscopy and other interventional techniques 8, injury-international journal of the care of the injured 8, eye 8, cornea 8, journal of clinical neuroscience 7, , Author Country, india 839, united states 36, united kingdom 29, australia 13, taiwan 6, japan 6, canada 6, south korea 5, singapore 5, germany 5).

Cluster {339}

Tertiary: Clinical Medicine and Human Patient Diseases cover pathology with focus on gastroenterology, dermatology, hematology and tropical medicine and hygiene.

SCI/SSCI Level 4: Cluster 339 (1,204 Records)

(**Themes:** patient 62.2%, diseas 1.7%, therapi 1.4%, clinic 1.2%, treatment 1.0%, control 0.7%, ag 0.5%, infect 0.5%, cancer 0.4%, symptom 0.4%, tuberculosi 0.4%, level 0.3%, surviv 0.3%, mean 0.3%, diagnosi 0.3%, diabet 0.3%, score 0.3%, test 0.3%, dose 0.3%, (73.01%)).

(**Keywords:** india 83, children 68, disease 67, diagnosis 60, therapy 59, prevalence 47, infection 45, expression 41, cancer 40, tuberculosis 39, management 36, efficacy 33, carcinoma 33, risk 32, trial 31, survival 30, chemotherapy 30, radiotherapy 26, prognosis 24, mortality 24, identification 23, association 23, serum 22, protein 22, plasma 22, infections 22, surgery 21, oxidative stress 21, cells 21, antibodies 21, squamous-cell carcinoma 20, risk-factors 20, gene 20, schizophrenia 19, radiation-therapy 19, pulmonary tuberculosis 19, epidemiology 19, experience 18, dna 18, hiv 17, follow-up 17, complications 17, classification 17, mutations 16, head 16, failure 16, disorders 16, aids 16, resistance 15, population 15).

SCI/SSCI Level 4: Cluster 339 Bibliometrics

(Author Affiliations: all india inst med sci 169, postgrad inst med educ & res 126, sanjay gandhi postgrad inst med sci 80, christian med coll & hosp 59, natl inst mental hlth & neurosci 42, tata mem hosp 38, banaras hindu univ 28, univ delhi 27, maulana azad med coll 20, king georges med univ 16, gb pant hosp 16, kasturba med coll & hosp 15, indian council med res 15, indian inst chem biol 13, lv prasad eye inst 12, kem hosp 12, govt med coll 12, sree chitra tirunal inst med sci & technol 11, univ coll med sci 10, univ calcutta 10, pgimer 9, icmr 9, apollo hosp 9, annamalai univ 9, univ washington 8).

(Authors: kumar, a 37, saxena, r 26, kumar, s 26, singh, s 25, kumar, r 23, srivastava, a 22, gupta, a 20, sharma, s 17, sarin, sk 15, gupta, s 15).

(Sources: neurology india 37, indian pediatrics 29, indian journal of medical research 29, journal of gastroenterology and hepatology 22, national medical journal of india 18, journal of surgical oncology 14, clinica chimica acta 14, world journal of gastroenterology 13, international journal of dermatology 12, transplantation proceedings 11, international journal of tuberculosis and lung disease 10, american journal of tropical medicine and hygiene 10, rheumatology international 9, annals of hematology 9, transactions of the royal society of tropical medicine and hygiene 8, renal failure 8, journal of medical microbiology 8, leprosy review 7, journal of the neurological sciences 7, international journal of leprosy and other mycobacterial diseases 7, haemophilia 7, bmc infectious diseases 7, american journal of ophthalmology 7, surgical neurology 6, radiotherapy and oncology 6).

(Author Country: india 1201, united states 121, united kingdom 50, canada 20, singapore 17, australia 17, germany 16, japan 13, thailand 12, china 12).

Cluster {495}

Tertiary: Environmental Sciences cover plant sciences, plant biochemistry and biotechnology focused on genetic resources and crop evolution; and geology focused on geophysical research.

SCI/SSCI Level 4: Cluster 495 (4,225 Records)

(**Themes:** speci 4.1%, popul 2.3%, indian 2.0%, ag 1.5%, area 1.4%, children 1.3%, region 1.3%, genet 1.3%, polymorph 1.0%, water 0.9%, health 0.9%, women 0.9%, sediment 0.8%, monsoon 0.8%, data 0.7%, high 0.7%, famili 0.6%, risk 0.6%, sea 0.6%, (24.27%)).

(**Keywords:** india 564, evolution 128, children 115, prevalence 100, population 100, diversity 94, model 85, mortality 76, identification 75, dna 71, risk 70, growth 67, geochemistry 66, disease 64, association 64, arabian sea 63, variability 62, genetic diversity 61, conservation 61, rapd 60, polymorphism 59, age 59, sediments 58, ocean 58, management 54, populations 53, markers 53, risk-factors 52, basin 52, women 48, water 48).

SCI/SSCI Level 4: Cluster 495 Bibliometrics

(**Author Affiliations:** indian inst technol 264, natl geophys res inst 156, natl inst oceanog 154, all india inst med sci 119, indian inst sci 109, phys res lab 73, univ delhi 69, indian stat inst 69, banaras hindu univ 66, postgrad inst med educ & res 61, indian council med res 60, geol survey india 57, indian inst trop meteorol 50, wadia inst himalayan geol 49, christian med coll & hosp 48, indian agr res inst 46, univ lucknow 44, sanjay gandhi postgrad inst med sci 43, ctr cellular & mol biol 43, jawaharlal nehru univ 41, univ calcutta 38, jadavpur univ 35, andhra univ 34, indian vet res inst 32, who 31).

(**Authors:** kumar, s 52, kumar, a 51, kumar, r 44, singh, s 41, sharma, a 32, singh, m 31, sharma, r 30, kumar, p 29, singh, r 28, sharma, s 28).

(**Sources:** current science 289, journal of the geological society of india 152, indian veterinary journal 83, indian pediatrics 81, geophysical research letters 69, journal of earth system science 57, indian journal of animal sciences 50, environmental monitoring and assessment 50, atmospheric environment 46, journal of asian earth sciences 39, indian journal of medical research 34, journal of environmental biology 32, gondwana research 31, international journal of remote sensing 30, indian journal of marine sciences 26, genetic resources and crop evolution 26, environmental geology 26, journal of geophysical research-atmospheres 25, indian journal of social work 24, euphytica 23, zootaxa 22, pure and applied geophysics 22, national medical journal of india 22, theoretical and applied genetics 20, medicine science and the law 20).
(**Author Country:** india 4217, united states 468, united kingdom 191, germany 112, japan 104, australia 80, france 79, canada 76, china 62, switzerland 47).

Cluster {489}

Tertiary: Molecular and Cellular Biochemistry, and Microbiology and Biotechnology cover plant sciences with focus on plant biochemistry and biotechnology.

SCI/SSCI Level 4: Cluster 489 (3,316 records)

(**Themes:** cell 14.6%, protein 7.4%, gene 6.0%, isol 3.5%, express 3.3%, infect 2.3%, sequenc 1.9%, strain 1.9%, hiv 1.4%, dna 1.3%, activ 1.1%, pcr 0.9%, resist 0.8%, human 0.8%, regul 0.7%, viru 0.6%, antigen 0.6%, immun 0.6%, transcript 0.6%, (50.80%)).
(**Keywords:** expression 311, identification 249, apoptosis 186, cells 171, protein 162, infection 157, gene 141, in-vitro 140, escherichia-coli 140, india 135, dna 117, proteins 115, gene-expression 104, activation 104, growth 103, strains 99, sequence 98, cancer 89, mice 84, binding 83, induction 82, resistance 80, inhibition 79, pcr 78, purification 76, in-vivo 72, disease 72, oxidative stress 65, genes 62, diagnosis 62).

SCI/SSCI Level 4: Cluster 489 Bibliometrics

(**Author Affiliations:** indian inst sci 149, univ delhi 115, indian vet res inst 113, indian inst technol 109, all india inst med sci 107, ctr cellular & mol biol 102, bose inst 73, indian inst chem biol 71, jawaharlal nehru univ 70, indian agr res inst 67, postgrad inst med educ & res 66, banaras hindu univ 66, natl inst cholera & enter dis 62, natl inst immunol 58, univ hyderabad 55, int ctr genet engn & biotechnol 54, bhabha atom res ctr 47, indian council med res 45, univ madras 44, tata inst fundamental res 44, natl ctr cell sci 42, cent drug res inst 41, inst microbial technol 39, ctr dna fingerprinting & diagnost 34, punjab agr univ 32).
(**Authors:** kumar, s 59, kumar, a 49, das, s 38, sharma, s 36, sharma, a 29, bhattacharya, sk 29, kumar, r 28, roy, s 27, ghosh, s 27, singh, s 26).
(**Sources:** indian journal of animal sciences 82, indian veterinary journal 77, current science 77, biochemical and biophysical research communications 56, journal of biological chemistry 51, indian journal of medical research 50, vaccine 42, molecular and cellular biochemistry 39, international journal of systematic and evolutionary microbiology 38, world journal of microbiology & biotechnology 27, journal of clinical microbiology 25, febs letters 25, journal of biosciences 20, journal of plant biochemistry and biotechnology 19, journal of food science and technology-mysore 19, indian journal of biochemistry & biophysics 19, aquaculture 19, fems microbiology letters 18, current microbiology 18, archives of virology 18, protein expression and purification 17, plant science 17, nucleic acids research 17, bioorganic & medicinal chemistry 17, journal of immunology 16).

(**Author Country:** india 3316, united states 375, japan 107, germany 101, united kingdom 73, france 46, australia 28, italy 26, china 25, south korea 24).

Cluster {462}

Tertiary: Molecular and Cellular Biochemistry, and Microbiology and Biotechnology cover plant sciences with specific focus on ethnopharmacology, phytotherapy research, medicinal food, toxicology and pharmacology.

SCI/SSCI Level 4: Cluster 462 (1951 Records)

(**Themes:** rat 11.5%, extract 5.3%, antioxid 4.8%, induc 3.6%, glutathion 2.3%, dose 2.2%, lipid 2.2%, activ 2.0%, level 1.9%, diabet 1.7%, peroxid 1.6%, liver 1.6%, mice 1.5%, enzym 1.2%, oxid 1.1%, lipid.peroxidation 1.1%, anim 1.0%, stress 1.0%, administr 1.0%, (49.79%)).

(**Keywords:** oxidative stress 367, lipid-peroxidation 342, lipid peroxidation 223, glutathione 202, rats 201, antioxidants 171, superoxide-dismutase 170, antioxidant 166, liver 156, mice 139, acid 135, assay 116, cells 115, toxicity 112, inhibition 109, damage 108, metabolism 107, rat 101, brain 100, free-radicals 98, cancer 96, antioxidant activity 83, in-vitro 82, antioxidant enzymes 76, flavonoids 67, induction 66, carcinogenesis 64, nitric-oxide 63).

SCI/SSCI Level 4: Cluster 462 Bibliometrics

(Author Affiliations: univ madras 221, annamalai univ 127, bhabha atom res ctr 88, panjab univ 85, ind toxicol res ctr 54, cent food technol res inst 54, cent drug res inst 47, all india inst med sci 47, maharaja sayajirao univ baroda 36, hamdard univ 36, jawaharlal nehru univ 35, univ rajasthan 34, jadavpur univ 33, kasturba med coll & hosp 32, indian inst chem biol 32, banaras hindu univ 30, csir 28, aligarh muslim univ 27, punjabi univ 26, def res & dev estab 24, postgrad inst med educ & res 23, indian vet res inst 23, inst nucl med & allied sci 21, sri venkateswara univ 20, indian inst chem technol 20).

(**Authors:** varalakshmi, p 42, chopra, k 28, kumar, a 27, kulkarni, sk 25, menon, vp 23, sultana, s 21, subramanian, s 21, sharma, s 21, singh, s 20, pari, l 19).

(**Sources:** molecular and cellular biochemistry 85, journal of ethnopharmacology 74, phytotherapy research 55, pharmaceutical biology 55, life sciences 46, journal of medicinal food 37, toxicology 32, clinica chimica acta 31, chemico-biological interactions 28, food chemistry 27, journal of pharmacy and pharmacology 26, toxicology mechanisms and methods 23, biological & pharmaceutical bulletin 21, phytomedicine 20, human & experimental toxicology 20, basic & clinical pharmacology & toxicology 19, environmental toxicology and pharmacology 18, pharmazie 17, journal of environmental pathology toxicology and oncology 16, journal of environmental biology 16, fitoterapia 16, food and chemical toxicology 15, indian veterinary journal 14, indian journal of biochemistry & biophysics 14, pharmacology biochemistry and behavior 13).

(**Author Country:** india 1951, united states 110, japan 27, germany 21, united kingdom 11, canada 11, south korea 10, singapore 7, argentina 5, malaysia 4).

Cluster {494}

Tertiary: Microbiology and Biotechnology cover environmental biology and plant sciences with focus on agricultural and food chemistry, and agronomy.

SCI/SSCI Level 4: Cluster 494 (3,835 Records)

(**Themes:** soil 5.4%, plant 4.6%, seed 2.9%, enzym 2.5%, oil 1.9%, crop 1.9%, product 1.9%, yield 1.7%, growth 1.7%, rice 1.6%, content 1.5%, activ 1.4%, acid 1.3%, root 1.3%, shoot 1.3%, wheat 1.2%, concentr 1.1%, level 1.1%, medium 0.9%, (38.18%)).

(**Keywords:** growth 341, purification 166, plants 135, yield 132, nitrogen 111, quality 109, soil 106, wheat 101, enzymes 94, degradation 91, india 87, proteins 86, protein 86, rice 82, storage 79, metabolism 79, acid 77, toxicity 76, leaves 71, cultures 69, management 66, bacteria 66, cattle 63, fermentation 61, expression 60, micropropagation 59, zinc 57, accumulation 57, culture 56, immobilization 53, essential oil composition 52).

SCI/SSCI Level 4: Cluster 494 Bibliometrics

(**Author Affiliations:** indian inst technol 148, indian agr res inst 143, punjab agr univ 132, cent food technol res inst 122, univ delhi 88, banaras hindu univ 76, natl dairy res inst 74, indian vet res inst 71, govind ballabh pant univ agr & technol 66, aligarh muslim univ 63, univ mysore 54, bhabha atom res ctr 54, csir 53, int crops res inst semi arid trop 47, guru nanak dev univ 45, tamil nadu agr univ 43, univ calcutta 41, natl bot res inst 39, cent inst med & aromat plants 38, reg res lab 36, haryana agr univ 35, panjab univ 32, ccs haryana agr univ 32, univ lucknow 31, natl chem lab 31).

(**Authors:** kumar, s 72, kumar, a 53, singh, s 46, singh, r 46, kumar, r 33, sharma, a 30, kumar, p 29, kumar, v 28, singh, j 25, sharma, s 25).

(**Sources**: journal of food science and technology-mysore 252, indian journal of animal sciences 155, indian journal of agricultural sciences 141, indian journal of agronomy 98, indian veterinary journal 93, current science 83, bioresource technology 80, journal of environmental biology 62, process biochemistry 53, world journal of microbiology & biotechnology 50, asian-australasian journal of animal sciences 50, in vitro cellular & developmental biology-plant 49, asian journal of chemistry 47, scientia horticulturae 44, journal of essential oil research 40, chemosphere 38, plant cell tissue and organ culture 32, flavour and fragrance journal 32, african journal of biotechnology 32, communications in soil science and plant analysis 31, food chemistry 30, journal of scientific & industrial research 29, biologia plantarum 28, enzyme and microbial technology 27, journal of plant biochemistry and biotechnology 25).

(**Author Country:** india 3834, united states 133, germany 54, south korea 47, japan 45, united kingdom 39, australia 23, china 21, france 20, canada 18).

Cluster {484}

Tertiary: Scientific and Industrial Research covers pattern recognition and machine intelligence with focus on production and operational research. This category also had two dis-similar thrusts including electric power components and applied computing and internet technology.

SCI/SSCI Level 4: Cluster 484 (3,719 Records)

(**Themes**: algorithm 8.6%, model 7.6%, network 5.0%, system 3.6%, paper 2.8%, optim 2.3%, imag 1.6%, design 1.6%, data 1.5%, time 1.4%, fuzzi 1.2%, set 1.1%, comput 1.1%, simul 1.0%, control 1.0%, oper 0.9%, neural 0.8%, cost 0.8%, paramet 0.7%, (45.04%)).

(**Keywords:** model 168, systems 149, optimization 148, design 124, genetic algorithm 117, algorithm 101, system 99, models 81, performance 77, simulation 74, networks 70, prediction 63, identification 63, algorithms 59, genetic algorithms 54, kinetics 53, classification 53, artificial neural network 50, neural networks 47, stability 42, india 42, dynamics 40, artificial neural networks 34, neural network 33, modeling 30, management 30, parameters 29, behavior 29, simulated annealing 28, recognition 28).

SCI/SSCI Level 4: Cluster 484 Bibliometrics

(**Author Affiliations:** indian inst technol 1117, indian inst sci 270, indian stat inst 159, jadavpur univ 104, natl inst technol 96, anna univ 89, ind technol inst 49, univ delhi 48, iit 48, indian inst management 44, bhabha atom res ctr 44, birla inst technol & sci 43, univ calcutta 40, tata inst fundamental res 36, jawaharlal nehru univ 28, banaras hindu univ 27, univ hyderabad 25, natl univ singapore 25, natl inst hydrol 25, natl inst foundry & forge technol 25, psg coll technol 24, natl chem lab 24, int inst informat technol 24, inst math sci 23, indira gandhi ctr atom res 23).

(**Authors:** kumar, s 47, kumar, a 47, kumar, r 42, chakraborty, s 30, tiwari, mk 29, chaudhuri, s 26, murthy, csr 23, das, s 23, roy, s 22, gupta, a 22).

(**Sources:** international journal of advanced manufacturing technology 70, pattern recognition and machine intelligence, proceedings 56, neural information processing 48, distributed computing and internet technology, proceedings 48, journal of scientific & industrial research 41, iete journal of research 39, current science 37, distributed computing - iwdc 2004, proceedings 32, industrial & engineering chemistry research 31, physica a-statistical mechanics and its applications 30, electric power components and systems 29, pattern recognition letters 28, defence science journal 27, intelligent information technology, proceedings 25, iete technical review 25, distributed computing - iwdc 2005, proceedings 25, applied mathematics and computation 25, applied computing, proceedings 25, physical review e 24, sadhana-academy proceedings in engineering sciences 22, pattern recognition 22, applied soft computing 22, international journal of production research 21, chemical engineering science 21, journal of materials processing technology 19).

(**Author Country:** india 3719, united states 377, united kingdom 87, germany 67, canada 61, france 51, singapore 50, china 45, japan 41, australia 31).

Cluster {497}

Tertiary: Astronomy and Astrophysics, and Nuclear and Particle Physics with focus on plasma physics and high energy physics.

SCI/SSCI Level 4: Cluster 497 (7,844 Records)

(**Themes:** model 2.1%, energi 2.0%, state 1.6%, equat 1.6%, wave 1.5%, flow 1.4%, function 1.2%, field 1.0%, theori 1.0%, frequenc 0.8%, system 0.8%, space 0.7%, two 0.7%, paramet 0.7%, experiment 0.7%, mode 0.6%, calcul 0.6%, densiti 0.6%, order 0.6%, (20.97%)).

(**Keywords:** model 387, systems 254, dynamics 192, flow 166, stability 137, scattering 136, states 118, spectroscopy 118, spectra 117, simulation 115, energy 113, emission 109, models 106, behavior 105, transition 103, temperature 101, system 101, propagation 96, state 93, design 93, field 91, equations 87, density 82, performance 80, particles 80, transport 79, light 79, waves 77, collisions 77, radiation 73).

SCI/SSCI Level 4: Cluster 497 Bibliometrics

(**Author Affiliations:** indian inst technol 1703, indian inst sci 547, tata inst fundamental res 489, bhabha atom res ctr 294, saha inst nucl phys 218, panjab univ 215, jadavpur univ 207, univ delhi 200, indian stat inst 184, inst high energy phys 182, banaras hindu univ 160, korea univ 149, univ sci & technol china 147, princeton univ 140, inst theoret & expt phys 132, indian inst astrophys 129, phys res lab 126, inst math sci 126, inst phys 123, brookhaven natl lab 121, indian assoc cultivat sci 120, sn bose natl ctr basic sci 119, univ tokyo 118, tokyo inst technol 118).

(**Authors:** kumar, a 154, zhang, zp 110, banerjee, s 104, li, j 103, kumar, s 101, matsumoto, t 91, kang, jh 90, kumar, r 86, chen, a 83, sengupta, s 80).

(**Sources:** physical review d 203, physical review letters 160, pramana-journal of physics 150, physical review b 146, physics letters b 130, physical review e 115, physical review c 113, indian journal of physics and proceedings of the indian association for the cultivation of science 113, journal of chemical physics 99, monthly notices of the royal astronomical society 96, physical review a 88, indian journal of pure & applied physics 84, astronomy & astrophysics 79, physics of plasmas 77, microwave and optical technology letters 66, astrophysical journal 63, journal of physics a-mathematical and general 61, journal of high energy physics 60, international journal of heat and mass transfer 60, applied mathematics and computation 59, modern physics letters a 56, journal of physics b-atomic molecular and optical physics 56, physica scripta 53, journal of applied physics 53).

(**Author Country:** india 7839, united states 921, germany 507, japan 336, france 323, china 299, united kingdom 282, russia 278, south korea 241, canada 188).

Cluster {499}

Tertiary: Thin Solid Films covers crystal growth research and technology with focus on nanoscience and nanotechnology, superconductor science and technology, and optoelectronics.

SCI/SSCI Level 4: Cluster 499 (4,806 Records)

(**Themes:** film 9.9%, temperatur 5.8%, magnet 2.7%, phase 2.2%, crystal 2.1%, sampl 1.7%, glass 1.6%, dope 1.4%, ion 1.4%, rai 1.3%, dielectr 1.3%, structur 1.1%, transit 1.1%, diffract 1.1%, optic 1.1%, electron 1.0%, field 1.0%, conduct 1.0%, composit 0.9%, (40.46%)).

(**Keywords:** thin-films 313, temperature 282, growth 266, films 258, nanoparticles 254, x-ray diffraction 215, behavior 215, system 194, optical-properties 183, ceramics 178, particles 177, conductivity 151, photoluminescence 146, transition 145, oxides 129, microstructure 129, magnetic-properties 129, spectra 128, luminescence 124, deposition 124, nanocrystals 121, xrd 113, transport 111, semiconductors 109, spectroscopy 106, thin films 100, oxide 94, electrical-properties 94, crystals 93, size 89).

SCI/SSCI Level 4: Cluster 499 Bibliometrics

(**Author Affiliations:** indian inst technol 709, bhabha atom res ctr 314, indian inst sci 297, indian assoc cultivat sci 198, natl chem lab 190, tata inst fundamental res 179, natl phys lab 159, univ delhi 116, ctr nucl sci 112, anna univ 104, indira gandhi ctr atom res 103, banaras hindu univ 100, shivaji univ 90, sri venkateswara univ 79, jawaharlal nehru ctr adv sci res 79, saha inst nucl phys 75, cochin univ sci & technol 73, inst phys 69, cent glass & ceram res inst 68, jadavpur univ 64, univ rajasthan 63, osmania univ 62, cent electrochem res inst 61, solid state phys lab 58, alagappa univ 58).

(**Authors:** kumar, a 94, kumar, r 75, avasthi, dk 74, kumar, s 64, tyagi, ak 63, malik, sk 52, gupta, a 50, ravi, v 48, rao, cnr 44, singh, s 42).

(**Sources:** physical review b 161, journal of applied physics 161, physica b-condensed matter 122, nuclear instruments & methods in physics research section b-beam interactions with materials and atoms 117, materials letters 117, indian journal of physics and proceedings of the indian association for the cultivation of science 114, bulletin of materials science 113,

indian journal of pure & applied physics 108, materials chemistry and physics 105, solid state communications 100, applied physics letters 97, ferroelectrics 96, journal of physics-condensed matter 86, journal of magnetism and magnetic materials 84, materials science and engineering b-solid state materials for advanced technology 76, journal of physics d-applied physics 73, journal of crystal growth 71, pramana-journal of physics 67, journal of materials science 66, crystal research and technology 64, thin solid films 63, materials research bulletin 63).
(**Author Country:** india 4806, japan 234, united states 230, germany 157, france 121, south korea 116, united kingdom 66, taiwan 60, italy 39, spain 28).

Cluster {498}
Tertiary: Physical chemistry covers hazardous materials with focus on chemical technology, colloid and interface science, and membrane separation and purification technology.
SCI/SSCI Level 4: Cluster 498 (5,745 Records)
(**Themes:** composit 2.0%, alloi 2.0%, adsorpt 1.9%, polym 1.9%, concentr 1.4%, acid 1.4%, blend 1.3%, ion 1.3%, surfac 1.3%, coat 1.1%, properti 1.1%, temperatur 1.1%, solut 1.0%, metal 1.0%, strength 0.9%, corros 0.9%, dye 0.9%, steel 0.9%, materi 0.8%, (25.11%)).
(**Keywords:** behavior 390, adsorption 359, kinetics 248, mechanical-properties 211, water 194, polymers 185, microstructure 180, acid 177, sorption 169, morphology 169, composites 154, removal 152, films 152, temperature 151, oxidation 141, degradation 134, mechanical properties 130, separation 122, blends 121, mechanism 104, activated carbon 100, alloys 98, derivatives 94, ions 93, system 92, performance 92, complexes 91, model 90, systems 88, stability 87).
SCI/SSCI Level 4: Cluster 498 Bibliometrics
(**Author Affiliations:** indian inst technol 1105, indian inst sci 238, bhabha atom res ctr 213, anna univ 148, natl inst technol 127, csir 115, natl chem lab 113, indira gandhi ctr atom res 109, indian inst chem technol 109, cent electrochem res inst 99, natl met lab 90, banaras hindu univ 90, jadavpur univ 85, cent leather res inst 78, def met res lab 72, aligarh muslim univ 71, karnatak univ 65, univ mysore 63, indian assoc cultivat sci 58, reg res lab 57, univ delhi 56, univ bombay 55, alagappa univ 53, andhra univ 52, mahatma gandhi univ 51).
(**Authors:** kumar, s 56, kumar, a 46, thomas, s 45, gupta, vk 45, aminabhavi, tm 45, singh, ak 42, singh, b 38, prakash, s 38, das, s 38, singh, s 36).
(**Sources:** journal of applied polymer science 330, asian journal of chemistry 139, journal of the indian chemical society 122, materials science and engineering a-structural materials properties microstructure and processing 112, transactions of the indian institute of metals 99, indian journal of chemical technology 94, journal of hazardous materials 74, journal of reinforced plastics and composites 60, journal of materials processing technology 57, journal of power sources 54, journal of colloid and interface science 54, journal of materials science 53, indian journal of chemistry section a-inorganic bio-inorganic physical theoretical & analytical chemistry 53, bulletin of materials science 50, journal of polymer materials 49, journal of scientific & industrial research 48, talanta 44, polymer international 42, bulletin of electrochemistry 42, metallurgical and materials transactions a-physical metallurgy and materials science 41, wear 40, materials science and technology 40, industrial & engineering chemistry research 40).

(**Author Country:** india 5742, united states 202, germany 141, south korea 108, japan 88, united kingdom 49, france 41, taiwan 30, china 22, australia 22).

Cluster {496}

Tertiary: Physical chemistry covers molecular liquids with focus on nano-metal chemistry and colloid and interface science.

SCI/SSCI Level 4: Cluster 496 (3,613 Records)

(**Themes:** complex 14.5%, ligand 3.7%, bond 3.6%, molecul 2.3%, structur 2.3%, interact 2.1%, hydrogen 1.8%, bind 1.7%, crystal 1.6%, compound 1.1%, ring 1.1%, surfact 0.9%, angstrom 0.8%, atom 0.8%, dna 0.8%, conform 0.8%, molecular 0.8%, titl 0.8%, form 0.7%, (43.25%)).

(**Keywords:** crystal-structure 361, complexes 232, derivatives 229, ligands 226, chemistry 177, crystal structure 165, water 158, binding 144, metal-complexes 140, nickel(ii) 131, crystal-structures 122, fluorescence 120, molecular-structure 117, acid 115, copper(ii) 110, systems 107, crystal 105, copper(ii) complexes 100, ligand 95, spectroscopy 92, cobalt(ii) 92, spectra 86, behavior 84, magnetic-properties 83, coordination 79, protein 76, viscosity 75, design 75, mechanism 71, aqueous-solution 71).

SCI/SSCI Level 4: Cluster 496 Bibliometrics

(**Author Affiliations:** indian inst technol 398, indian inst sci 263, jadavpur univ 149, indian inst chem technol 120, indian assoc cultivat sci 113, bhabha atom res ctr 113, univ delhi 102, univ mysore 97, univ hyderabad 97, univ madras 85, aligarh muslim univ 80, univ rajasthan 78, bharathidasan univ 76, univ burdwan 58, guru nanak dev univ 57, natl chem lab 54, mangalore univ 53, karnatak univ 50, univ calcutta 49, cent leather res inst 49, annamalai univ 48, ne hill univ 47, madurai kamaraj univ 47, univ sains malaysia 45, univ barcelona 43).

(**Authors:** yathirajan, hs 66, ravikumar, k 62, kumar, a 49, fun, hk 46, nethaji, m 44, sharma, s 41, kumar, r 38, drew, mgb 38, butcher, rj 37, sridhar, b 35).

(**Sources:** acta crystallographica section e-structure reports online 301, journal of the indian chemical society 140, indian journal of chemistry section a-inorganic bio-inorganic physical theoretical & analytical chemistry 117, spectrochimica acta part a-molecular and biomolecular spectroscopy 106, polyhedron 95, asian journal of chemistry 94, inorganica chimica acta 84, transition metal chemistry 78, journal of physical chemistry b 71, inorganic chemistry 65, journal of organometallic chemistry 54, chemical physics letters 50, journal of chemical sciences 46, journal of molecular liquids 44, european journal of inorganic chemistry 43, journal of physical chemistry a 42, journal of molecular structure 40, journal of colloid and interface science 38, colloids and surfaces a-physicochemical and engineering aspects 35, journal of chemical and engineering data 34, langmuir 32, synthesis and reactivity in inorganic metal-organic and nano-metal chemistry 31, chemical communications 31, journal of photochemistry and photobiology a-chemistry 30).

(**Author Country:** india 3613, united states 221, germany 153, united kingdom 137, spain 68, japan 65, france 53, italy 52, malaysia 47, taiwan 44).

Cluster {0}

Tertiary: Inorganic Chemistry and Physical Chemistry covers crystal growth research and technology with focus on crystallography, crystal growth and design, and radiation physics (detection) and chemistry.

SCI/SSCI Level 4: Cluster 0 (484 Records)

(**Themes:** dot 47.9%, center 36.8%, bond 1.0%, dot.hydrogen 0.8%, center.dot.hydrogen 0.8%, hydrogen 0.8%, titl 0.7%, title.compound 0.6%, ring 0.6%, crystal 0.6%, molecul 0.5%, compound 0.4%, interact 0.3%, dot.hydrogen.bonds 0.3%, hydrogen.bonds 0.3%, structur 0.3%, intermolecular.center.dot 0.3%, intermolecular.center 0.3%, intermolecular 0.2%, dot.interactions 0.2%).

(**Keywords:** crystal-structure 60, complexes 38, crystal structure 33, acid 28, derivatives 23, crystal-structures 22, x-ray 21, crystal 20, molecular-structure 19, coordination polymers 17, patterns 15, diffraction 14, ligands 13, design 13, magnetic-properties 12, chemistry 12, pulse radiolysis 11, chalcone derivatives 11, networks 10, molecules 10, hydrogen bonding 10, aqueous-solution 10, monohydrate 9, mechanism 9, hydrogen-bonds 9).

SCI/SSCI Level 4: Cluster 0 Bibliometrics

(**Author Affiliations:** univ madras 65, indian inst chem technol 60, indian inst sci 51, univ sains malaysia 48, indian inst technol 48, mangalore univ 37, bharathidasan univ 36, univ mysore 31, univ hyderabad 31, bhabha atom res ctr 26, anna univ 25, jadavpur univ 20, univ aberdeen 19, madurai kamaraj univ 19, panjab univ 12, univ jammu 11, univ barcelona 11, cent salt & marine chem res inst 11, indian assoc cultivat sci 9, howard univ 9, univ st andrews 8, madura coll 8, pa coll engn 7, natl inst technol 7, univ burdwan 6).

(**Authors:** ravikumar, k 52, fun, hk 49, velmurugan, d 31, razak, ia 22, patil, ps 21, dharmaprakash, sm 21, yathirajan, hs 20, chinnakali, k 20, sridhar, b 17, natarajan, s 16).

(**Sources:** acta crystallographica section e-structure reports online 204, acta crystallographica section c-crystal structure communications 27, crystal growth & design 20, polyhedron 16, journal of chemical crystallography 15, inorganic chemistry communications 12, crystengcomm 10, journal of physical chemistry a 9, european journal of inorganic chemistry 9, inorganic chemistry 8, journal of coordination chemistry 6, radiation physics and chemistry 5, journal of molecular structure 5, inorganica chimica acta 5, physical review b 4, journal of organometallic chemistry 4, chemical communications 4, biopolymers 4, transition metal chemistry 3, spectrochimica acta part a-molecular and biomolecular spectroscopy 3, journal of physical chemistry b 3, journal of chemical sciences 3, zeitschrift fur naturforschung section b-a journal of chemical sciences 2, tetrahedron 2, synthesis and reactivity in inorganic metal-organic and nano-metal chemistry 2).

(**Author Country:** india 484, malaysia 49, united kingdom 39, united states 22, germany 21, spain 14, taiwan 6, switzerland 6, italy 6, china 6).

Cluster {445}

Tertiary: Molecular and Cellular Biochemistry covers organic and biomolecular chemistry with focus on heterocyclic chemistry, bioorganic and medicinal chemistry, and pharmaceutical research.

SCI/SSCI Level 4: Cluster 445 (1,926 Records)

(**Themes:** compound 13.7%, substitut 5.2%, synthes 3.6%, aryl 3.5%, activ 2.8%, beta 2.2%, methyl 2.1%, reaction 2.0%, deriv 1.9%, phenyl 1.9%, acid 1.8%, condens 1.6%, yield 1.5%, nmr 1.5%, spectral 1.3%, alpha 1.3%, antibacteri 1.2%, amino 1.1%, hydroxi 1.1%, (52.37%)).

(**Keywords:** derivatives 325, agents 122, synthesis 95, antimicrobial activity 85, antibacterial activity 79, chemistry 75, inhibitors 71, acid 60, analogs 51, complexes 47, antibacterial 45, organic-synthesis 43, cyclization 41, esters 40, heterocycles 38, acids 35, asymmetric-synthesis 33, alkaloids 33, route 31, microwave irradiation 31, design 31, aldehydes 30, stereoselective-synthesis 28, qsar 27, potent 26, ketones 26, identification 25, carbonyl-compounds 25, biological-activity 25, antifungal activity 25).

SCI/SSCI Level 4: Cluster 445 Bibliometrics

(**Author Affiliations:** indian inst chem technol 113, cent drug res inst 110, indian inst technol 100, univ rajasthan 50, natl chem lab 47, mangalore univ 35, univ delhi 33, csir 32, sri venkateswara univ 31, kakatiya univ 31, univ madras 30, univ mysore 29, karnatak univ 29, dr reddys labs ltd 28, jadavpur univ 27, univ lucknow 26, indian inst sci 25, bharathiar univ 24, kurukshetra univ 23, univ hyderabad 22, indian assoc cultivat sci 22, aligarh muslim univ 22, indian inst chem biol 21, guru nanak dev univ 21, kuvempu univ 20).

(**Authors:** kumar, a 36, kumar, s 27, kumar, r 25, singh, s 21, rao, ks 19, singh, p 18, das, b 18, shukla, pk 17, desai, kr 17, singh, b 15).

(**Sources:** indian journal of chemistry section b-organic chemistry including medicinal chemistry 238, indian journal of heterocyclic chemistry 187, tetrahedron letters 120, asian journal of chemistry 110, bioorganic & medicinal chemistry letters 81, journal of the indian chemical society 68, tetrahedron 67, synthetic communications 67, bioorganic & medicinal chemistry 65, heterocyclic communications 48, european journal of medicinal chemistry 38, phosphorus sulfur and silicon and the related elements 37, journal of heterocyclic chemistry 35, synthesis-stuttgart 31, journal of chemical research-s 28).

(**Author Country:** india 1926, united states 48, japan 24, germany 21, united kingdom 18, france 17, austria 8, taiwan 7, denmark 7, south korea 6).

Cluster {481}

Tertiary: Physical Chemistry and Molecular and Cellular Biochemistry cover molecular synthesis and catalysis with focus on chemical science and kinetics, and medicinal chemistry.

SCI/SSCI Level 4: Cluster 481 (2,530 Records)

(**Themes:** reaction 14.0%, catalyst 10.6%, synthesi 5.7%, yield 3.6%, oxid 3.0%, acid 2.9%, solvent 1.4%, alcohol 1.1%, kinet 1.1%, effici 1.1%, rate 1.0%, select 0.9%, aldehyd 0.9%, step 0.9%, product 0.9%, catalyt 0.9%, condit 0.8%, correspond 0.7%, activ 0.7%, (52.73%)).

(**Keywords:** derivatives 290, oxidation 286, kinetics 254, alcohols 206, aldehydes 163, mechanism 161, acid 151, organic-synthesis 147, chemistry 135, complexes 116, ketones 106, efficient 103, catalysis 94, carbonyl-compounds 91, water 87, microwave irradiation 84, reduction 80, esters 74, catalyst 74, alkylation 72, amines 69, conversion 67, asymmetric-synthesis 65, efficient synthesis 63, mild 60, acids 60, cleavage 59, solvent-free conditions 58, reagent 58, catalysts 58).

SCI/SSCI Level 4: Cluster 481 Bibliometrics

(**Author Affiliations:** indian inst chem technol 367, indian inst technol 250, natl chem lab 232, indian inst sci 103, cent drug res inst 72, univ delhi 53, csir 51, univ bombay 49, reg res lab 47, univ madras 45, bangalore univ 44, indian assoc cultivat sci 41, anna univ 40, cent salt & marine chem res inst 34, ne hill univ 33, jadavpur univ 33, bhabha atom res ctr 32, annamalai univ 32, karnatak univ 31, indian inst petr 29, univ allahabad 27, def res & dev estab 27, univ mumbai 26, cent leather res inst 26, univ hyderabad 25).

(**Authors:** yadav, js 72, kantam, ml 37, das, b 34, yadav, gd 31, kumar, a 31, mahanti, mk 30, reddy, bvs 28, nandibewoor, st 28, kumar, p 26, kumar, s 25).

(**Sources:** tetrahedron letters 391, journal of molecular catalysis a-chemical 144, synthetic communications 125, indian journal of chemistry section b-organic chemistry including medicinal chemistry 116, tetrahedron 82, oxidation communications 82, synlett 69, journal of the indian chemical society 68, journal of organic chemistry 68, journal of chemical research-s 62, synthesis-stuttgart 61, catalysis communications 56, tetrahedron-asymmetry 55, applied catalysis a-general 50, arkivoc 43, indian journal of chemistry section a-inorganic bio-inorganic physical theoretical & analytical chemistry 42, asian journal of chemistry 31, organic letters 27, journal of heterocyclic chemistry 25, journal of catalysis 25, european journal of organic chemistry 24, letters in organic chemistry 23, international journal of chemical kinetics 23, industrial & engineering chemistry research 23).
(**Author Country:** india 2530, united states 70, japan 41, germany 37, united kingdom 21, france 18, south korea 15, belgium 7, taiwan 6, switzerland 6).

APPENDIX D

EC DATABASE TAXONOMIES
(2005-2006)

Taxonomy Diagram and Node Details

EC Taxonomy (2005-2006)

Engineering Compendex (2005-2006) Hierarchical Taxonomy (Levels 0 - 4)

Level 0	Level 1	Level 2	Level 3	Level 4
				Cluster {485} - 909 records chemical synthesis colloid and interface science reaction kinetics / surface active agents / surfactants
				Cluster {474} - 865 records colloid and interface science reaction kinetics / surface active agents / surfactants separation and purification techniques
				Cluster {481} - 1,216 records organic compounds chemical synthesis molecular catalysis / chemical oxidation and reaction kinetics
				Cluster {487} - 1,313 records organic compounds chemical synthesis molecular organic crystals
			Cluster {495} - 1,774 records physical chemistry polymer science and technology chemical synthesis colloid and interface science	Cluster {488} - 1,963 records chemical synthesis/doping polycrystalline and nanostructured materials ferroelectric and magnetic materials
		Cluster {503} - 4,303 records physical chemistry polymer science and technology	Cluster {500} - 2,529 records polymer science and technology organic compounds chemical synthesis	Cluster {496} - 2,272 records chemical synthesis/doping polycrystalline and nanostructured materials crystal structure and growth research single crystals and surface coatings
Cluster {510} - 23,584 records APPLIED PHYSICAL SCIENCES CHEMICAL ENGINEERING COMPUTERS AND DATA PROCESSING AGRICULTURE ENGINEERING & FOOD TECHNOLOGY ELECTRONICS & COMMUNICATION ENGINEERING	Cluster {508} - 9,456 records APPLIED PHYSICAL SCIENCES CHEMICAL ENGINEERING	Cluster {505} - 5,153 records physical chemistry materials engineering	Cluster {501} - 4,235 records physical chemistry materials engineering chemical synthesis/doping polycrystalline and nanostructured materials	Cluster {361} - 533 records polycrystalline and nanostructured materials thin solid films solar energy / solar cell research / deposition techniques
	Cluster {509} - 14,128 records COMPUTERS AND DATA PROCESSING AGRICULTURE ENGINEERING & FOOD TECHNOLOGY ELECTRONICS & COMMUNICATION ENGINEERING	Cluster {507} - 9,654 records applied computation polymer science and technology food science and technology	Cluster {405} - 918 records materials engineering polycrystalline and nanostructured materials thin solid films	Cluster {310} - 385 records nanostructured materials thin solid films semi-conductor materials / sol-gels electrochemistry and electrodeposition
		Cluster {504} - 4,474 records applied computation communications	Cluster {506} - 6,307 records polymer science and technology food science and technology organic compounds microbiology and biotechnology	Cluster {498} - 2,310 records organic compounds polymer composites and plastics / materials characterization
			Cluster {499} - 3,347 records applied computation chemical engineering mathematical models and computer simulation	Cluster {502} - 3,997 records microbiology and biotechnology agronomy / plant biochemistry and biotechnology environmental biology / genetic resources and crop evolution
			Cluster {486} - 1,630 records applied computation communications mathematical models and computer simulation telecommunications	Cluster {470} - 1,178 records chemical engineering mathematical models and computer simulation computational fluid dynamics / heat mass transfer
			Cluster {497} - 2,844 records applied computation communications mathematical models and computer simulation telecommunications	Cluster {489} - 2,169 records mathematical models and computer simulation computational fluid dynamics / plasma physics Monte Carlo and molecular dynamics
				Cluster {476} - 975 records mathematical models and computer simulation telecommunications microelectronics / VLSI Circuit Design
				Cluster {458} - 655 records mathematical models and computer simulation electrical power and distribution systems fuzzy and intelligent control
				Cluster {483} - 1,004 records mathematical models and computer simulation telecommunications artificial intelligence / neural networks wireless telecommunication networks
				Cluster {493} - 1,840 records mathematical models and computer simulation pattern recognition and machine intelligence artificial intelligence / genetic algorithms / remote sensing information retrieval / data mining

EC Level 1:

Level 1 is divided into two clusters with the following primary and secondary category headings:

Cluster {508}

Primary: APPLIED PHYSICAL SCIENCES and CHEMICAL ENGINEERING

Secondary: Physical Chemistry, Materials Engineering and Polymer Science and Technology.

EC Level 1: Cluster {508} - 9,456 records

(**Themes:** film 3.3%, temperatur 2.3%, ion 1.8%, reaction 1.4%, phase 1.3%, crystal 1.3%, structur 1.1%, oxid 1.1%, acid 1.1%, electron 1.0%, complex 0.9%, deg 0.9%, sampl 0.9%, concentr 0.9%, catalyst 0.8%, energi 0.7%, rai 0.7%, coat 0.7%, magnet 0.7%, (23.34%)).

(**Keywords:**synthesis (chemical) 1113, x ray diffraction analysis 611, reaction kinetics 554 x ray diffraction 518, scanning electron microscopy 443, fourier transform infrared spectroscopy 426, synthesis (chemical) 396, ph effects 348, thermal effects 345, electric conductivity 340, solutions 337, oxidation 333, concentration (process) 328, nanostructured materials 322, doping (additives) 297, transmission electron microscopy 290, catalysts 283 crystal structure 272, nanostructured materials 262, phase transitions 256, mathematical models 254, x ray diffraction analysis 234, morphology 231, adsorption 231, fluorescence 229, permittivity 228, molecular structure 220, complexation 217, microstructure 215 thermogravimetric analysis 208).

Cluster {509}

Primary: COMPUTERS AND DATA PROCESSING, AGRICULTURE ENGINEERING & FOOD TECHNOLOGY, and ELECTRONICS & COMMUNICATION ENGINEERING.

Secondary: Applied Computation, Polymer Science and Technology, Food Science and Technology, and Communications.

EC Level 1: Cluster {509} - 14,128 records

(**Themes:** model 2.4%, system 1.9%, algorithm 1.2%, paper 1.2%, control 1.0%, network 1.0%, design 0.9%, flow 0.8%, time 0.8%, power 0.8%, data 0.8%, paramet 0.7%, simul 0.7%, two 0.6%, gener 0.6%, number 0.6%, optim 0.6%, comput 0.5%, oper 0.5%, (18.13%)).

(**Keywords:** mathematical models 1017, mathematical models 895, computer simulation 819, algorithms 561, computer simulation 553, optimization 482, problem solving 467, parameter estimation 361, finite element method 276, thermal effects 254, optimization 238, algorithms 210, microstructure 195, electric potential 193, natural frequencies 185, neural networks 182, computational methods 180, proteins 179, approximation theory 177,algorithms 175, scanning electron microscopy 174, functions 170, genetic algorithms 168, ph effects 166, statistical methods 163, problem solving 163, concentration (process) 160, enzymes 159, reynolds number 153, matrix algebra 151).

EC Level 4:

Level 4 is divided into sixteen (16) clusters. They are described in order of their listing in Table 24, starting from the top with the following tertiary category headings and single technology focus areas:

Cluster {485}

Tertiary: Chemical Synthesis and Colloid and Interface Science covers reaction kinetics and surface active agents / surfactants with focus on polymerization and monomers.

EC Level 4: Cluster 485 (909 Records)

(**Themes:** copolym 5.5%, surfact 4.1%, polym 4.1%, micel 3.9%, graft 3.2%, polymer 2.3%, viscos 2.1%, poli 1.4%, solut 1.3%, mixtur 1.3%, concentr 1.2%, acid 1.1%, monom 1.1%, hydrogel 1.0%, water 1.0%, solvent 1.0%, micellar 0.9%, delta 0.9%, methyl 0.8%, (38.97%)).

(Keywords: synthesis (chemical) 134, viscosity 89, surface active agents 85, monomers 82, solutions 74, fourier transform infrared spectroscopy 70, micelles 64,synthesis (chemical) 63, polymerization 62, molecular weight 58, scanning electron microscopy 55, nuclear magnetic resonance spectroscopy 55, reaction kinetics 53, concentration (process) 53, composition 49, crosslinking 48, fluorescence 46, thermogravimetric analysis 44, thermal effects 43, solvents 43, differential scanning calorimetry 39, hydrophobicity 37, copolymerization 37, infrared spectroscopy 35, binary mixtures 34, characterization 33, activation energy 32, ph effects 31, solubility 30, polymers 30).

EC Level 4: Cluster 485 Bibliometrics

(**Author Affiliations:** indian institute of technology 71, indian institute of science 31, guru nanak dev university 28, national chemical laboratory 24, bhabha atomic research centre 24, central leather research institute 21, university of allahabad 19, sri krishnadevaraya university 19, jadavpur university 19, karnatak university 18, anna university 17, aligarh muslim university 17, indian institute of chemical technology 14, sardar patel university 13, himachal pradesh university 13, veer narmad south gujarat university 12, south gujarat university 12, panjab university 12, university of mumbai 11, north bengal university 11, annamalai university 10, university institute of engineering and technology 9, regional research laboratory 9, polymer science unit 9, indian association for the cultivation of science 9). (**Authors:** bakshi, mandeep singh 23, bajpai, s.k. 15, kabir-ud-din 14, brar, a.s. 14, aswal, v.k. 13, kumar, sanjeev 11, aminabhavi, tejraj m. 11, mukherjee, tulsi 10, kumar, anil 10, oswal, s.l. 9,

(**Sources:** j. appl. polym. sci. 114, j chem eng data 39, j mol liq 38, colloids surf. a physicochem. eng. asp. 34, j. colloid interface sci. 32, j polym sci part a 32, j phys chem b 30, j macromol sci pure appl chem 29, react funct polym 20, polym. int. 20, j chem thermodyn 20, langmuir 18, polymer 17, j. dispersion sci. technol. 17, des monomers polym 17, phys. chem. liq. 16, eur polym j 16, colloid polym. sci. 16, carbohydr polym 16, j chem phys 12, chem. phys. lett. 12, thermochim acta 11, int j polym mater 11, spectrochim. acta part a mol. biomol. spectrosc. 9, radiat. phys. chem. 8).

Cluster {474}

Tertiary: Colloid and Interface Science covers reaction kinetics and surface active agents/surfactants with focus on separation and purification techniques and chromatography.

EC Level 4: Cluster 474 (865 Records)

(**Themes:** adsorpt 13.0%, dye 7.1%, remov 4.7%, adsorb 3.7%, concentr 2.4%, extract 1.9%, ion 1.8%, degrad 1.6%, sorption 1.3%, kinet 1.2%, isotherm 1.2%, acid 1.2%, solut 1.0%, carbon 0.9%, cod 0.9%, langmuir 0.9%, column 0.8%, wastewat 0.8%, rate 0.8%, (48.07%)).

(**Keywords:** ph effects 187, adsorption 143, concentration (process) 106, solutions 93, reaction kinetics 85, adsorption isotherms 55, adsorption 55, isotherms 54, mathematical models 48, activated carbon 43, dyes 40, sorption 39, desorption 38, degradation 38, adsorbents 38, ph effects 34, extraction 30, diffusion 30, thermal effects 28, positive ions 28, oxidation 28, effluents 28, chemical oxygen demand 28, mass spectrometry 26, ion exchange 26, biomass 26, surface active agents 23, rate constants 23, wastewater 22, photocatalysis 22).

EC Level 4: Cluster 474 Bibliometrics

(**Author Affiliation:** indian institute of technology 96, anna university 51, indian institute of technology roorkee 38, university of mumbai 18, regional research laboratory 18, bhabha atomic research centre 17, aligarh muslim university 15, central leather research institute 14, regional research laboratory (csir) 12, indian institute of science 12, bharathiar university 12, banaras hindu university 12, national environmental engineering research institute 11, indian institute of technology kanpur 11, national metallurgical laboratory 10, indian institute of chemical technology 10, guru nanak dev university 10, gauhati university 9, indian institute of technology-roorkee 8, university of kerala 7, national chemical laboratory 7, indian institute of technology guwahati 7, defence research and development establishment 7, annamalai university 7, sri venkateswara university 6).

(**Authors:** gupta, v.k. 24, velan, m. 13, palanivelu, k. 12, gupta, a.k. 12, pal, anjali 11, mittal, alok 11, vijayaraghavan, k. 10, namasivayam, c. 10, sivanesan, s. 9, saxena, puja 9).

(**Sources:** j. hazard. mater. 72, bioresour. technol. 43, talanta 36, j. colloid interface sci. 34, ind. eng. chem. res. 31, sep. purif. technol. 25, anal. chim. acta 24, sep. sci. technol. 22, j. chromatogr. b anal. technol. biomed. life sci. 22, dyes pigm. 19, j. planar chromatogr. mod. tlc 18, process biochem. 16, j. chromatogr. a 16, water res. 14, sens actuators, b chem 14, colloids surf. a physicochem. eng. asp. 14, chemosphere 14, chem. eng. j. 14, j. chem. technol. biotechnol. 13, j. appl. polym. sci. 13, int. j. environ. pollut. 12, hydrometallurgy 12, j. sep. sci. 10, chem. eng. world 9, toxicol. environ. chem. 8).

Cluster {481}

Tertiary: Organic Compounds and Chemical Synthesis covers molecular catalysis with focus on chemical oxidation and reaction kinetics, catalysts and organic solvents.

EC Level 4: Cluster 481 (1,216 Records)

(**Themes**: catalyst 15.2%, reaction 13.4%, oxid 3.7%, acid 3.6%, activ 1.9%, yield 1.8%, synthesi 1.3%, catalyt 1.3%, product 1.1%, rate 1.0%, kinet 1.0%, select 0.9%, solvent 0.7%, alcohol 0.7%, alkyl 0.6%, convers 0.6%, georg.thieme.verlag 0.6%, copy.georg.thieme 0.6%, georg.thieme 0.6%, (51.09%)).

(**Keywords:** reaction kinetics 235, synthesis (chemical) 231, catalysts 219, oxidation 149, synthesis (chemical) 143, catalysis 142, catalyst activity 89, alcohols 82, reaction kinetics 76, rate constants 61, oxidation 60, solvents 56, catalysts 51, x ray diffraction

49, x ray diffraction analysis 49, amines 49, aldehydes 47, fourier transform infrared spectroscopy 44, derivatives 41, aromatic compounds 40, alkylation 40, catalysis 39, substitution reactions 38, phenols 38, esters 38, complexation 37, reaction kinetics 37, methanol 35, thermal effects 34, surface active agents 34, ph effects 34, , ,

EC Level 4: Cluster 481 Bibliometrics

(**Author Affiliations:** indian institute of chemical technology 108, national chemical laboratory 106, indian institute of technology 75, indian institute of science 31, bhabha atomic research centre 31, anna university 31, central drug research institute 24, cochin university of science and technology 20, indian association for the cultivation of science 19, university of mumbai 18, regional research laboratory (CSIR) 17, university of madras 16, university institute of chemical technology 16, indian institute of petroleum 16, regional research laboratory 15, indian institute of chemical biology 15, bangalore university 15, university of pune 14, karnatak university 14, jadavpur university 14, indian institute of technology madras 14, annamalai university 14, university institute of chemical technology (uict) 12, indian institute of technology roorkee 12, indian institute of technology guwahati 12).

(**Authors:** yadav, ganapati d. 26, halligudi, s.b. 21, yadav, j.s. 20, das, biswanath 18, sugunan, s. 16, khan, zaheer 16, singh, a.p. 12, pradhan, narayan c. 12, jasra, raksh v. 12, parida, k.m. 11).

(**Sources**: j. mol. catal. a chem. 164, synthesis 97, j. org. chem. 82, catal. commun. 66, appl catal a gen 52, ind. eng. chem. res. 37, j. catal. 26, microporous mesoporous mater. 25, j. chem. sci. 24, int j chem kinet 24, org. biomol. chem. 23, transition met chem 22, carbohydr. res. 20, can. j. chem. 20, res chem intermed 17, j. colloid interface sci. 16, helv. chim. acta 16, catal lett 13, j. organomet. chem. 11, radiat. phys. chem. 10, j phys chem b 10, heteroatom chem. 10, j. appl. polym. sci. 9, j phys chem a 9, colloid polym. sci. 9).

Cluster {487}

Tertiary: Organic Compounds and Chemical Synthesis with focus on molecular organic crystals, molecular and crystal structure and molecular and biomolecular spectroscopy.

EC Level 4: Cluster 487 (1,313 Records)

(**Themes**: complex 12.1%, bond 4.1%, ligand 3.2%, molecul 3.1%, hydrogen 2.0%, prime 1.6%, structur 1.5%, fluoresc 1.4%, interact 1.3%, midline.ellipsis 1.2%, ellipsi 1.2%, midlin 1.2%, iii 1.2%, state 1.0%, compound 0.8%, conform 0.8%, spectra 0.8%, solvent 0.8%, molecular 0.8%, (40.94%)).

(**Keywords:** synthesis (chemical) 210, hydrogen bonds 150, complexation 136, molecular structure 132, crystal structure 111, fluorescence 110, complexation 99, reaction kinetics 81, synthesis (chemical) 79, molecular dynamics 73, conformations 70, chemical bonds 63, infrared spectroscopy 60, solvents 57, probability density function 55, nuclear magnetic resonance spectroscopy 55, spectroscopic analysis 54, charge transfer 48, single crystals 46, fourier transform infrared spectroscopy 45, x ray diffraction analysis 43, molecular structure 43, absorption 42, oxidation 41, electrochemistry 41, amines 41, quantum theory 40, hydrogen bonds 40, characterization 39, amino acids 39).

EC Level 4: Cluster 487 Bibliometrics

(**Author Affiliations:** indian institute of technology 97, indian institute of science 90, indian association for the cultivation of science 38, bhabha atomic research centre 37, university of hyderabad 34, indian institute of chemical technology 30, university of delhi 29, jadavpur university 28, panjab university 25, north-eastern hill university 23, bharathiar university 23, saha institute of nuclear physics 22, annamalai university 21, indian institute of technology bombay 20, university of burdwan 19, university of pune 18, central leather research institute 18, university of madras 17, karnatak university 16, indian institute of technology madras 15, sardar patel university 14, indian institute of technology kanpur 14, university of jammu 13, banaras hindu university 12, aligarh muslim university 12).

(**Authors:** chandra, sulekh 24, nethaji, munirathinam 22, sharma, raj pal 19, pati, swapan k. 17, bala, ritu 17, sharma, rajni 16, krishnakumar, v. 16, subramanian, v. 15, mukherjee, t. 14, sathyamurthy, n. 13).

(**Sources:** spectrochim. acta part a mol. biomol. spectrosc. 161, transition met chem 75, j phys chem a 71, j. organomet. chem. 59, j phys chem b 58, j. mol. struct. 57, chem. phys. lett. 53, j. chem. sci. 46, j chem phys 40, acta crystallogr sect c cryst struct commun 35, int j quantum chem 23, dalton trans. 22, chem. eur. j. 20, angew. chem. int. ed. 20, j. org. chem. 18, appl. organomet. chem. 18, organometallics 13, org. biomol. chem. 13, langmuir 13, j. am. chem. soc. 13, biopolymers 13, biochemistry 12, res chem intermed 11, j therm anal calor 11, j mol liq 11).

Cluster {488}

Tertiary: Chemical Synthesis/Doping and Polycrystalline and Nanostructured Materials with focus on ferroelectric and magnetic materials.

EC Level 4: Cluster 488 (1,963 Records)

(**Themes:** temperatur 5.5%, magnet 4.3%, dielectr 3.1%, transit 3.0%, phase 2.6%, glass 2.3%, sampl 2.2%, state 2.0%, conduct 1.9%, energi 1.6%, dope 1.5%, electron 1.4%, structur 1.1%, pressur 1.0%, ion 0.9%, field 0.9%, equal 0.9%, compound 0.9%, frequenc 0.8%, (38.72%)).

(**Keywords:** electric conductivity 186, doping (additives) 141, permittivity 136, phase transitions 130, magnetization 123, synthesis (chemical) 114, x ray diffraction analysis 111, thermal effects 103, x ray diffraction 99, mathematical models 90, dielectric properties 79, x ray diffraction analysis 74, polycrystalline materials 73, activation energy 66, magnetic properties 64, substitution reactions 60, sintering 59, magnetic susceptibility 55, microstructure 53, lattice constants 52, glass 52, pressure effects 51, phonons 51, light absorption 51, crystallization 50, optical properties 48, superconducting transition temperature 47, crystal structure 47, composition 47, positive ions 46).

EC Level 4: Cluster 488 Bibliometrics

(**Author Affiliations:** indian institute of technology 146, indian institute of science 98, bhabha atomic research centre 77, indian association for the cultivation of science 47, tata institute of fundamental research 43, banaras hindu university 40, indian institute of technology madras 38, national physical laboratory 35, osmania university 33, university of hyderabad 30, sri venkateswara university 29, indira gandhi centre for atomic research 24, indian institute of technology bombay 21, university of delhi 18, jadavpur university 18, regional research laboratory (csir) 17, pondicherry university 17, punjabi university 16, saha institute of nuclear physics 15, indian institute of technology kanpur 15, indian institute of technology guwahati 15, guru nanak dev university 15, university campus 14, shivaji university 14, cochin university of science and technology 14).

(**Authors:** choudhary, r.n.p. 42, tyagi, a.k. 26, malik, s.k. 26, rai, s.b. 17, nigam, a.k. 17, veeraiah, n. 16, thakur, o.p. 15, prakash, chandra 15, chougule, b.k. 15, varma, k.b.r. 14).
(**Sources:** j appl phys 105, phys b condens matter 91, j phys condens matter 83, solid state commun 76, pramana j phys 73, j magn magn mater 51, ferroelectrics 50, j phys chem solids 49, j chem phys 49, appl phys lett 42, bull mater sci 41, phys rev a 40, j non cryst solids 33, mater sci eng b solid state adv technol 32, mater chem phys 32, j phys d 32, mater lett 31, chem. phys. lett. 31, j mater sci 29, j phys b at mol opt phys 27, j alloys compd 27, phys rev lett 24, radiat. phys. chem. 22, j phys chem b 22, spectrochim. acta part a mol. biomol. spectrosc. 21).

Cluster {496}
Tertiary: Chemical Synthesis/Doping and Polycrystalline and Nanostructured Materials covers crystal structure and growth research with focus on single crystals and surface coatings.
EC Level 4: Cluster 496 (2,272 Records)
(**Themes:** crystal 5.6%, coat 4.5%, membran 3.3%, powder 2.2%, ion 2.1%, nanoparticl 1.6%, deg 1.5%, size 1.5%, rai 1.5%, particl 1.4%, corros 1.3%, irradi 1.3%, temperatur 1.3%, phase 1.2%, surfac 1.2%, grown 0.9%, diffract 0.9%, sampl 0.9%, electron 0.8%, (35.86%)).
(**Keywords:** synthesis (chemical) 325, x ray diffraction analysis 284, x ray diffraction 219, transmission electron microscopy 203, scanning electron microscopy 193, fourier transform infrared spectroscopy 170, nanostructured materials 161, nanostructured materials 149, morphology 113, crystal growth 107, scanning electron microscopy 106, microstructure 100, x ray diffraction analysis 95, thermogravimetric analysis 94, crystallization 92, photoluminescence 87, particle size analysis 79, crystal structure 76, precipitation (chemical) 75, synthesis (chemical) 75, sintering 74, evaporation 72, crystalline materials 71, thermal effects 69, solutions 69, sol-gels 69, fourier transform infrared spectroscopy 68, transmission electron microscopy 67, electrochemistry 66, doping (additives) 66).
EC Level 4: Cluster 496 Bibliometrics
(**Author Affiliations:** indian institute of technology 177, national chemical laboratory 84, indian institute of science 75, bhabha atomic research centre 69, anna university 68, central electrochemical research institute 63, indian association for the cultivation of science 40, karnatak university 39, university of pune 38, central glass and ceramic research institute 37, institute of physics 36, indian institute of chemical technology 33, university of delhi 32, national metallurgical laboratory 30, indian institute of technology madras 30, indian institute of technology roorkee 26, national physical laboratory 25, loyola college 24, national institute of technology 23, national aerospace laboratories 23, university of madras 22, saha institute of nuclear physics 20, alagappa university 20, tezpur university 19, central salt and marine chemicals research institute 19).
(**Authors:** avasthi, d.k. 63, ravi, v. 43, prakash, s. 39, ramasamy, p. 31, venkatachari, g. 24, kanjilal, d. 24, tyagi, a.k. 23, singh, f. 23, sridhar, s. 22, kar, soumitra 22).
(**Sources:** j cryst growth 76, bull mater sci 65, surf. coat. technol. 64, cryst res technol 64, mater lett 63, technovation 52, mater chem phys 52, j mater sci 50, j. membr. sci. 45, j. appl. polym. sci. 43, j phys chem b 41, j appl phys 40, nucl instrum methods phys res sect b 37, j am ceram soc 36, j. nanosci. nanotechnol. 34, mater res bull 33, appl phys lett 30, mater sci

eng b solid state adv technol 29, appl surf sci 29, pramana j phys 28, j power sources 26, nanotechnology 24, ceram int 24, mater. sci. eng. a 23, chem. phys. lett. 22).

Cluster {361}

Tertiary: Polycrystalline and Nanostructured Materials and Thin Solid Films covers solar energy / solar cell research with focus on deposition techniques and optical properties.

EC Level 4: Cluster 361 (533 Records)

(**Themes:** film 37.6%, deposit 8.2%, thin 6.3%, thin.films 5.6%, substrat 3.0%, optic 1.6%, films.deposited 1.3%, temperatur 0.8%, gap 0.8%, band.gap 0.8%, anneal 0.7%, band 0.7%, glass 0.6%, rai 0.5%, sputter 0.5%, glass.substrates 0.5%, structur 0.5%, electr 0.5%, dope 0.4%, (71.32%)).

(**Keywords:** thin films 104, x ray diffraction 83, deposition 82, thin films 78, x ray diffraction analysis 74, optical properties 72, glass 67, substrates 62, scanning electron microscopy 60, annealing 51, evaporation 50, electric conductivity 47, synthesis (chemical) 44, polycrystalline materials 42, morphology 41, atomic force microscopy 39, electric properties 38, doping (additives) 38, electrodeposition 37, nanostructured materials 35, sol-gels 33, magnetron sputtering 32, film growth 32, x ray photoelectron spectroscopy 30, photoluminescence 30, light absorption 30, pyrolysis 28, pulsed laser deposition 28, microstructure 27, atomic force microscopy 27).

EC Level 4: Cluster 361 Bibliometrics

(**Author Affiliations:** shivaji university 40, indian institute of technology 34, indian institute of science 29, cochin university of science and technology 25, jadavpur university 24, sri venkateswara university 21, central electrochemical research institute 16, indian association for the cultivation of science 13, alagappa university 13, university of pune 11, national physical laboratory 11, bharathiar university 11, kongunadu arts and science college 10, indian institute of technology delhi 10, anna university 10, university of delhi 9, bhabha atomic research centre 9, indian institute of technology madras 8, department of instrumentation 8, tata institute of fundamental research 6, solid state physics laboratory 6, energy research unit 6, cochin univ. of sci. and technology 6, bengal engineering and science university 6, university of rajasthan 5).

(**Authors:** chattopadhyay, k.k. 19, vijayakumar, k.p. 18, patil, p.s. 14, murali, k.r. 14, lokhande, c.d. 13, sanjeeviraja, c. 11, narayandass, sa.k. 11, mangalaraj, d. 11, sadale, s.b. 10, pal, a.k. 10).

(**Sources:** appl surf sci 38, thin solid films 35, sol energ mater sol cells 25, j appl phys 22, bull mater sci 21, mater chem phys 18, mater lett 17, j phys d 15, j cryst growth 15, mater sci eng b solid state adv technol 13, j phys chem solids 13, vacuum 12, phys b condens matter 12, appl phys lett 12, solid state commun 11, semicond sci technol 10, mater res bull 10, j mater sci 10, j mater sci mater electron 9, ferroelectrics 9, cryst res technol 9, surf. coat. technol. 8, phys status solidi a 8, j non cryst solids 7, appl phys a 6).

Cluster {310}

Tertiary: Nanostructured Materials and Thin Solid Films cover solid-state/semi-conductor materials, with focus on electrochemistry, electrodeposition and sol-gels.

EC Level 4: Cluster 310 (385 Records)

(**Themes:** film 61.1%, thick 1.0%, thin 0.7%, surfac 0.6%, polym 0.6%, dope 0.6%, deposit 0.6%, substrat 0.5%, electrod 0.5%, conduct 0.4%, nanoparticl 0.4%, electrochem 0.4%, oxid

0.4%, temperatur 0.3%, optic 0.3%, thin.films 0.3%, composit 0.3%, properti 0.3%, microscopi 0.3%, (69.93%)).

(**Keywords:** thin films 71, scanning electron microscopy 45, synthesis (chemical) 38, nanostructured materials 38, thin films 36, electrochemistry 29, fourier transform infrared spectroscopy 28, doping (additives) 28, atomic force microscopy 27, electric conductivity 26, morphology 24, nanostructured materials 24, sol-gels 23, x ray diffraction analysis 22, x ray diffraction 19, optical properties 18, microstructure 18, polymers 17, electrodeposition 17, cyclic voltammetry 17, transmission electron microscopy 15, oxidation 15, substrates 14, annealing 14, photoluminescence 13, electrodes 13, deposition 13, atomic force microscopy 13, absorption 13, x ray photoelectron spectroscopy 12).

EC Level 4: Cluster 310 Bibliometrics

(**Author Affiliations:** indian institute of technology 33, national physical laboratory 25, indian institute of science 20, central electrochemical research institute 13, saha institute of nuclear physics 10, indian institute of technology delhi 10, university of delhi 9, bhabha atomic research centre 9, university of hyderabad 8, technical physics and prototype engineering division 8, shivaji university 8, alagappa university 7, anna university 6, tripura university 5, indian association for the cultivation of science 5, chemistry and physics of materials unit 5, central glass and ceramic research institute 5, sree narayana college 4, raman research institute 4, pratap college 4, north maharashtra university 4, indian assoc. the cultiv. of sci. 4, centre for materials for electronics technology (c-met) 4, banaras hindu university 4, university of madras 3).

(**Authors:** agnihotry, s.a. 20, deepa, m. 10, yakhmi, j.v. 9, srivastava, a.k. 9, verma, amita 8, sharma, ashutosh 8, bakhshi, a.k. 8, trivedi, d.c. 7, gupta, s.k. 7, mulik, u.p. 6).

(**Sources:** sens actuators, b chem 16, j appl phys 15, thin solid films 13, pramana j phys 12, bull mater sci 12, mater lett 10, mater chem phys 10, j. appl. polym. sci. 10, synth met 9, chem. phys. lett. 9, appl surf sci 9, appl phys lett 9, sol energ mater sol cells 8, j mater sci 8, mater sci eng b solid state adv technol 6, langmuir 6, polymer 5, polym degradation stab 5, phys b condens matter 5, j. nanosci. nanotechnol. 5, vacuum 4, phys. rev. e stat. nonlinear soft matter phys. 4, j. colloid interface sci. 4, j macromol sci pure appl chem 4, j electrochem soc 4).

Cluster {498}

Tertiary: Organic Compounds with focus on polymer composites and plastics, materials characterization and microstructure and material properties.

EC Level 4: Cluster 498 (2,310 Records)

(**Themes:** oil 3.7%, composit 3.6%, alloi 3.4%, strength 2.9%, blend 2.4%, fiber 2.3%, crack 2.1%, stress 2.0%, concret 1.9%, weld 1.7%, properti 1.6%, wear 1.6%, steel 1.4%, mechan 1.3%, materi 1.3%, reinforc 1.2%, tensil 1.1%, load 1.1%, resin 0.8%, (38.35%)).

(**Keywords:** microstructure 164, scanning electron microscopy 152, tensile strength 132, mechanical properties 124, mathematical models 104, scanning electron microscopy 99, composite materials 90, morphology 87, strength of materials 75, thermal effects 72, composition 72, synthesis (chemical) 69, differential scanning calorimetry 69, wear of materials 68, hardness 63, deformation 63, elastic moduli 62, friction 61, curing 61, crack initiation 61, thermogravimetric analysis 60, stress analysis 60, gas chromatography 60, crosslinking 60, strain 59, mathematical models 59, x ray diffraction analysis 58, stresses 53, compressive strength 53, surface roughness 50).

EC Level 4: Cluster 498 Bibliometrics

(**Author Affiliations:** indian institute of technology 306, indian institute of science 96, national institute of technology 91, indian institute of technology madras 66, bhabha atomic research centre 43, mahatma gandhi university 39, indian institute of technology delhi 36, anna university 35, regional research laboratory 34, cochin university of science and technology 33, jadavpur university 29, university of mysore 27, national metallurgical laboratory 27, banaras hindu university 23, regional research laboratory (csir) 22, defence metallurgical research laboratory 22, indian institute of technology bombay 20, indian institute of chemical technology 19, sardar patel university 18, metallurgy and materials group 16, central institute of medicinal and aromatic plants 16, central electrochemical research institute 15, materials research laboratory 13, deemed university 13, central glass and ceramic research institute 13).

(**Authors:** thomas, sabu 38, bhowmick, anil k. 26, das, s. 23, raj, baldev 22, narayanasamy, r. 18, das, c.k. 18, gnanamoorthy, r. 16, ahmad, sharif 16, kishore 15, jayakumar, t. 15).

(**Sources:** j. appl. polym. sci. 153, mater. sci. eng. a 103, j reinf plast compos 60, j mater sci 50, j. essent. oil res. 46, indian concr j 42, mater. sci. technol. 37, polym.-plast. technol. eng. 32, flavour fragrance j. 30, j mater process technol 29, int j polym mater 29, wear 28, j struct eng 27, metall mat trans a phys metall mat sci 25, bull mater sci 25, scripta mater 23, mater manuf process 23, polym. int. 20, j food sci technol 20, int j adv manuf technol 20, isij int 19, polymer 17, prog. rubber plast. recycling technol. 16, proc. world tribol. cong. 16, mater lett 15).

Cluster {502}

Tertiary: Microbiology and Biotechnology covers agronomy/plant and food sciences and environmental biology with focus on plant biochemistry and biotechnology, genetic resources and crop evolution. Environmental monitoring and impact assessment covers computer simulation and modeling of rain/ground water (ph effects, adsorption, and contamination).

EC Level 4: Cluster 502 (3,997 Records)

(**Themes**: soil 2.6%, product 2.2%, water 2.1%, enzym 1.8%, protein 1.8%, plant 1.6%, model 1.4%, system 1.3%, activ 1.1%, cell 1.1%, design 1.0%, level 0.9%, concentr 0.9%, acid 0.8%, area 0.7%, deg 0.6%, dry 0.6%, content 0.6%, growth 0.5%, (24.00%)).

(**Keywords:** mathematical models 201, mathematical models 184, proteins 153, ph effects 143, enzymes 143, bacteria 120, soils 111, plants (botany) 93, cells 93, concentration (process) 92, computer simulation 89, biomass 83, genes 82, computer simulation 82, optimization 81, moisture 79, thermal effects 76, crops 73, remote sensing 71, environmental impact 71, fermentation 69, bacteria 67, parameter estimation 64, optimization 64, enzymes 63, rain 62, growth kinetics 61, amino acids 61, dna 60, contamination 59).

EC Level 4: Cluster 502 Bibliometrics

(**Author Affiliations:** indian institute of technology 316, indian institute of science 148, national institute of oceanography 72, indian institute of technology delhi 53, central food technological research institute 48, punjab agricultural university 47, guru nanak dev university 41, central leather research institute 41, bhabha atomic research centre 41, anna university 40, aligarh muslim university 37, jadavpur university 36, indian institute of technology bombay 36, university of delhi 32, indian agricultural research institute 32, banaras hindu university 32, jawaharlal nehru university 30, national institute of hydrology 27, university of mumbai 25, national geophysical research institute 25, indian institute of technology madras 25, regional research laboratory 23, national environmental engineering research institute 23, tamil nadu agricultural university 21, space physics laboratory 21).

(**Authors:** kumar, s. 17, satheesh, s.k. 16, kumar, rakesh 15, gupta, a.k. 15, bawa, a.s. 15, tiwari, g.n. 14, singh, narpinder 13, sinha, sarita 12, pandey, ashok 12, gupta, s.k. 12).

(**Sources:** j food sci technol 218, proc spie int soc opt eng 99, world j. microbiol. biotechnol. 89, environ. monit. assess. 79, process biochem. 69, bioresour. technol. 68, j. biol. chem. 63, geophys. res. lett. 59, chemosphere 49, ippta 47, atmos. environ. 47, int. j. remote sens. 41, plant cell tissue organ cult. 36, ama agric mech asia afr lat am 34, enzyme microb. technol. 33, environ. geol. 33, j food eng 32, appl. microbiol. biotechnol. 30, phytomorpholohy 29, chem. eng. world 29, biochemistry 29, biotechnol. lett. 24, agric. water manage. 24, plant sci. 23, def sci j 23).

Cluster {470}

Tertiary: Chemical Engineering and Mathematical Models and Computer Simulation covers computational fluid dynamics with focus on heat mass transfer.

EC Level 4: Cluster 470 (1,178 Records)

(**Themes:** flow 16.3%, heat 6.2%, fluid 3.9%, model 2.4%, heat.transfer 2.3%, veloc 2.1%, transfer 2.0%, number 1.8%, equat 1.3%, liquid 1.2%, pressur 1.2%, convect 1.1%, wall 1.1%, ga 1.1%, field 1.0%, reynold 0.9%, turbul 0.9%, numer 0.8%, experiment 0.8%, (49.06%)).

(**Keywords:** mathematical models 149, mathematical models 137, reynolds number 132, heat transfer 106, computer simulation 106, computer simulation 84, computational fluid dynamics 74, mass transfer 56, flow of fluids 52, thermal effects 50, nusselt number 47, viscosity 46, navier stokes equations 46, heat flux 45, velocity measurement 44, porous materials 44, parameter estimation 44, boundary conditions 44, laminar flow 41, turbulence 40, pressure effects 39, diffusion 38, heat transfer 38, hydrodynamics 37, numerical analysis 36, problem solving 35, flow patterns 34, drag 34, shear stress 29, nozzles 29).

EC Level 4: Cluster 470 Bibliometrics

(**Author Affiliations:** indian institute of technology 234, indian institute of science 73, indian institute of technology madras 64, university of mumbai 30, national institute of technology 29, indian institute of technology kanpur 21, indian institute of technology guwahati 21, anna university 19, gulbarga university 16, indian institute of technology delhi 15, jadavpur university 13, indian institute of chemical technology 12, national aerospace laboratories 11, indian institute of technology bombay 11, tata steel 10, indian institute of technology roorkee 10, university of rajasthan 9, industrial flow modeling group 9, indian statistical institute 9, engineering mechanics unit 8, bharathiar university 8, saha institute of nuclear physics 7, iit madras 7, bhabha atomic research centre 7, sri venkateswara college of engineering 6, institute for plasma research 6).

(**Authors:** chakraborty, suman 20, chhabra, r.p. 17, joshi, jyeshtharaj b. 16, das, p.k. 15, biswas, g. 13, prasad, d.h.l. 12, tulapurkara, e.g. 11, sunil 11, das, manab kumar 11, vittal prasad, t.e. 9).

(**Sources:** int. j. heat mass transf. 65, chem. eng. sci. 33, pramana j phys 30, ind. eng. chem. res. 27, heat mass transfer 17, j. heat transf. 16, j. fluid mech. 15, phys. fluids 14, phys rev lett 14, numer heat transfer part a appl 14, int. j. therm. sci. 13, int j fluid mech res 13, chem. eng. res. des. 13, modell meas control b 12, isij int 12, int. commun. heat mass transf. 12, proc. asme turbo expo 11, phys. rev. e stat. nonlinear soft matter phys. 11, int. j. numer. methods fluids 11, chem. eng. world 11, aiche j. 11, phys. plasmas 10, j porous media 10, chem. eng. j. 10, can. j. chem. eng. 10).

Cluster {489}

Tertiary: Mathematical Models and Computer Simulation covers computational fluid dynamics with focus on microwave optics, plasma physics and Monte Carlo and molecular dynamics simulations.

EC Level 4: Cluster 489 (2,169 Records)

(**Themes:** wave 5.5%, equat 2.6%, beam 2.4%, frequenc 2.0%, laser 1.8%, element 1.6%, model 1.6%, nonlinear 1.4%, numer 1.3%, plate 1.2%, antenna 1.2%, finit 1.2%, mode 1.0%, dynam 0.9%, plasma 0.8%, system 0.8%, puls 0.8%, function 0.8%, two 0.8%, (30.55%)).

(**Keywords:** mathematical models 222, finite element method 176, mathematical models 161, computer simulation 142, natural frequencies 117, computer simulation 89, problem solving 88, perturbation techniques 79, parameter estimation 79, approximation theory 77, boundary conditions 71, functions 57, numerical analysis 54, damping 54, differential equations 52, eigenvalues and eigenfunctions 51, numerical methods 49, matrix algebra 49, bandwidth 49, finite element method 48, stiffness 46, shear deformation 44, nonlinear equations 43, vibrations (mechanical) 40, problem solving 39, electrons 39, computational methods 39, wave propagation 37, elasticity 37, deformation 37).

EC Level 4: Cluster 489 Bibliometrics

(**Author Affiliations:** indian institute of technology 271, indian institute of science 169, indian institute of technology madras 68, indian institute of technology delhi 52, tata institute of fundamental research 46, banaras hindu university 43, centre for advanced technology 41, cochin university of science and technology 36, indian statistical institute 34, university of delhi 33, indian institute of technology bombay 32, institute for plasma research 27, bhabha atomic research centre 27, jadavpur university 23, national institute of technology 21, anna university 21, indian association for the cultivation of science 19, indian institute of technology guwahati 18, saha institute of nuclear physics 17, birla institute of technology 17, physical research laboratory 16, university of calcutta 14, indian institute of technology kanpur 14, kurukshetra university 13, institute of mathematical sciences 12).

(**Authors:** mohanan, p. 28, ganesan, n. 19, aanandan, c.k. 19, gopalakrishnan, s. 17, vasudevan, k. 16, tripathi, v.k. 16, mohanty, r.k. 16, mathew, k.t. 14, kapuria, s. 14, gupta, p.k. 14).

(**Sources:** pramana j phys 76, phys. rev. e stat. nonlinear soft matter phys. 69, j sound vib 69, microwave opt technol lett 68, phys. plasmas 60, appl math comput (new york) 54, proc spie int soc opt eng 45, j chem phys 36, phys rev lett 27, phys rev a 27, phys scr 25, chaos solitons fractals 25, appl. opt. 23, compos. struct. 22, astron. astrophys. 22, opt commun 21, j struct eng 19, rev. sci. instrum. 18, j reinf plast compos 18, proc indian acad sci math sci 17, sadhana 16, asia pacif microwave conf proc apmc 16, opt eng 15, ocean eng. 15, phys a stat mech appl 14).

Cluster {476}

Tertiary: Mathematical Models and Computer Simulation, and Telecommunications covers microelectronics with focus on VLSI circuit design.

EC Level 4: Cluster 476 (975 Records)

(**Themes:** filter 5.7%, signal 4.1%, current 3.8%, gate 3.5%, circuit 3.5%, voltag 2.9%, channel 2.7%, nois 2.3%, devic 2.3%, simul 1.4%, ieee 1.3%, design 1.2%, power 1.1%, frequenc 1.1%, model 0.9%, digit 0.9%, paper 0.9%, error 0.8%, system 0.8%, (41.88%)).

(**Keywords:** computer simulation 157, computer simulation 80, mathematical models 63, mathematical models 62, algorithms 58, electric potential 55, signal to noise ratio 47, electric currents 45, signal processing 40, optimization 40, capacitance 40, leakage currents 34, threshold voltage 31, parameter estimation 31, gates (transistor) 28, bit error rate 28, cmos integrated circuits 26, electrodes 24, natural frequencies 23, electric conductivity 23, thin films 22, bandwidth 22, spurious signal noise 21, error analysis 20, electric fields 20, activation energy 20, current voltage characteristics 19, communication channels (information theory) 19, optimization 17, mosfet devices 17).

EC Level 4: Cluster 476 Bibliometrics

(**Author Affiliations:** indian institute of technology 178, indian institute of science 46, indian institute of technology madras 26, indian institute of technology delhi 21, jadavpur university 20, national institute of technology 19, international institute of information technology 16, indian institute of technology bombay 13, banaras hindu university 13, university of delhi south campus 12, mahatma gandhi university 12, anna university 12, university of delhi 11, netaji subhas institute of technology 10, indian institute of technology kanpur 9, harcourt butler technological institute 9, saha institute of nuclear physics 8, indian school of mines 8, indian association for the cultivation of science 8, university of kashmir 7, vidyasagar university 6, solid state physics laboratory 6, osmania university 6, indian statistical institute 6, indian institute of technology guwahati 6).

(**Authors:** maiti, c.k. 21, gupta, r.s. 20, gupta, mridula 17, kumar, m. jagadesh 15, srinivas, m.b. 14, kumar, a. 13, menon, c.s. 12, yegnanarayana, b. 11, thapliyal, himanshu 11, chakraborty, s. 11).

(**Sources:** proc ieee int conf vlsi des 40, iete j res 26, solid-state electron. 23, ieee trans. electron devices 20, ieee int conf person wireless commun 19, semicond sci technol 18, proc spie int soc opt eng 18, signal process 17, j appl phys 17, proc. int. conf. intelligent sensing info. proces. 16, proc. indicon 2005 int. conf. ieee india council 15, thin solid films 14, microelectron int 12, appl phys lett 12, opt commun 11, j. circuits syst. comput. 10, opt eng 9, ieee trans signal process 9, microelectron eng 8, int. j. electron. 8, eur. conf. speech commun. technol. 8, wseas trans. circuits syst. 7, pramana j phys 7, microwave opt technol lett 7, j non cryst solids 7).

Cluster {458}

Tertiary: Mathematical Models and Computer Simulation covers electrical power and distribution systems with focus on fuzzy and intelligent control and instruments and measurement.

EC Level 4: Cluster 458 (655 Records)

(**Themes:** control 27.2%, voltag 6.0%, power 5.1%, system 5.1%, convert 2.1%, switch 1.6%, fuzzi 1.5%, simul 1.2%, current 1.1%, motor 1.1%, load 1.1%, ieee 0.9%, oper 0.9%, scheme 0.9%, output 0.8%, paper 0.8%, model 0.7%, design 0.7%, invert 0.6%, (59.84%)).

(**Keywords:** computer simulation 102, electric potential 81, mathematical models 64, computer simulation 59, electric loads 48, control equipment 40, mathematical models 39, algorithms 37, computer simulation 37, fuzzy sets 33, neural networks 30, electric inverters 30, electric currents 29, electric power systems 27, parameter estimation 26, pulse width modulation 25, optimization 24, voltage control 23, capacitors 23, induction motors 22, power control 21, robustness (control systems) 20, fuzzy control 20, feedback control 20, vectors 19, system stability 19, sensors 19, computer software 18, electric drives 17, closed loop control systems 17).

EC Level 4: Cluster 458 Bibliometrics

(**Author Affiliations:** indian institute of technology 125, indian institute of science 52, national institute of technology 26, anna university 23, indian institute of technology delhi 20, indian institute of technology bombay 15, pondicherry engineering college 12, indian institute of technology madras 11, visvesvaraya national institute of technology 8, annamalai university 8, psg college of technology 7, department of instrumentation and control engineering 7, raman research institute 6, jadavpur university 6, institute for plasma research 6, jawaharlal nehru technological university 5, indian institute of technology kanpur 5, dept. of electrical engineering 5, department of instrumentation 5, i.i.t.delhi 4, i.i.t. delhi 4, college of engineering 4, birla institute of technology and science 4, bharathiar university 4, vellore institute of technology 3).

(**Authors:** singh, bhim 29, chidambaram, m. 15, bhuvaneswari, g. 15, bandyopadhyay, b. 15, gopakumar, k. 13, garg, vipin 13, kanchan, r.s. 10, ghosh, arindam 10, sundarapandian, v. 9, tekwani, p.n. 8).

(**Sources:** 2006 ieee power india conf. 51, electr. power comp. syst. 21, proc int conf power electron drive syst 17, iee proc electr power appl 17, ieee trans power delivery 16, proc. indicon 2005 int. conf. ieee india council 14, electr power syst res 13, ser. energy power syst. 12, ieee trans power electron 11, power eng. soc. gen. meet. 10, ieee trans power syst 10, ieee trans ind electron 9, proc ieee int conf ind technol 8, ind. eng. chem. res. 8, iee proc gener transm distrib 8, proc. int. conf. intelligent sensing info. proces. 7, iete tech rev 7, icems 2005 proc. 8th int. conf. electric. machines and syst. 7, epe j eur power electron drives j 7, adv model anal c 7, smart mater struct 6, proc sice annu conf 6, modell meas control a 6, j guid control dyn 6, isa trans 6).

Cluster {483}

Tertiary: Mathematical Models and Computer Simulation, and Telecommunications covers artificial intelligence and wireless telecommunication networks with focus on neural networks and wireless network optimization.

EC Level 4: Cluster 483 (1,004 records)

(**Themes:** network 27.7%, node 4.0%, neural 3.8%, protocol 2.2%, neural.network 2.1%, mobil 2.0%, model 1.6%, algorithm 1.5%, wireless 1.2%, scheme 1.1%, secur 1.1%, rout 1.1%, inform 1.0%, servic 1.0%, train 0.9%, packet 0.9%, ann 0.9%, commun 0.9%, paper 0.9%, (56.74%)).

(**Keywords:** algorithms 118, computer simulation 103, mathematical models 99, neural networks 96, mathematical models 94, network protocols 82, computer simulation 75, quality of service 57, routers 56, optimization 55, algorithms 52, telecommunication traffic 48, problem solving 48, internet 47, neural networks 47, bandwidth 43, wireless telecommunication systems 42, security of data 40, network protocols 39, telecommunication networks 37, backpropagation 37, database systems 34, probability 33, packet networks 33, wireless telecommunication systems 32, algorithms 32, topology 28, computational complexity 28, telecommunication networks 28, learning systems 26).

EC Level 4: Cluster 483 Bibliometrics

(**Author Affiliations:** indian institute of technology 148, indian institute of science 62, anna university 34, national institute of technology 26, indian institute of technology madras 24, jadavpur university 19, indian statistical institute 16, applied research group 14, university of calcutta 11, pondicherry engineering college 11, international institute of information technology 11, indian institute of technology roorkee 10, psg college of technology 9, national institute of hydrology 8, indian institute of technology delhi 8, ibm india research laboratory 8, jawaharlal nehru university 7, institute of mathematical sciences 7, sri venkateswara college of engineering 6, jataayu software (p) ltd. 6, indian institute of technology bombay 6, deemed university 6, indian institute of technology kharagpur 5, honeywell technology solutions lab. 5, birla institute of technology and science 5).

(**Authors:** siva ram murthy, c. 15, manoj, b.s. 14, srivatsa, s.k. 11, sridhar, v. 11, shanmugavel, s. 9, murthy, c. siva ram 9, saha, debashis 8, kumar, rajeev 8, gopalan, srividya 8, vaidehi, v. 7).

(**Sources:** lect. notes comput. sci. 68, ieee int conf person wireless commun 59, iete tech rev 22, iete j res 22, inf. technol. j. 21, proc. int. conf. intelligent sensing info. proces. 15, proc. indicon 2005 int. conf. ieee india council 15, phys a stat mech appl 15, 2005 13th ieee int. conf. netw. jointly w. 2005 7th ieee malaysia int. conf. communic. proc. 12, wseas trans. comput. 11, wseas trans. commun. 11, proc spie int soc opt eng 9, int j adv manuf technol 9, electron libr 9, proc. int. conf. netw. int. conf. syst. int. conf. mobile com. learn. technol. 7, sadhana 6, proc. world wireless congr. wwc 6, int. conf. inf. technol. coding comput. 6, expert sys appl 6, comput. networks 6, proc. int. conf. internet multimedia syst. appl. 5, proc. int. conf. computat. intell. modell. ctrl. automat. cimca 2005 int. conf. intell. agents web technol. i-net commerce 5, phys. rev. e stat. nonlinear soft matter phys. 5).

Cluster {493}

Tertiary: Mathematical Models and Computer Simulation covers pattern recognition and machine intelligence, and artificial intelligence with focus on genetic algorithms, intelligent remote sensing, and information retrieval/data mining.

EC Level 4: Cluster 493 (1,840 Records)

(**Themes:** algorithm 11.7%, imag 8.7%, optim 3.6%, set 2.1%, paper 1.5%, springer.verlag 1.2%, copy.springer.verlag 1.2%, system 1.2%, comput 1.2%, berlin 1.2%, heidelberg 1.2%, springer.verlag.berlin 1.2%, verlag.berlin 1.2%, data 1.1%, fuzzi 1.1%, model 0.8%, copy.springer 0.8%, gener 0.8%, cluster 0.8%, (43.19%)).

(**Keywords:** algorithms 253, problem solving 226, optimization 194, mathematical models 146, mathematical models 128, genetic algorithms 111, algorithms 97, algorithms 94, computer simulation 88, optimization 73, problem solving 68, computer simulation 67, computational methods 67, computational complexity 67, database systems 65, parameter estimation 60, functions 59, image analysis 51, constraint theory 51, feature extraction 48, fuzzy sets 47, heuristic methods 46, problem solving 46, set theory 44, approximation theory 44, image processing 43, costs 41, theorem proving 40, pattern recognition 39, statistical methods 38).

EC Level 4: Cluster 493 Bibliometrics

(**Author Affiliations:** indian institute of technology 236, indian institute of science 118, indian statistical institute 82, national institute of technology 45, indian institute of technology madras 43, indian institute of technology delhi 36, anna university 34, jadavpur university 30, indian institute of technology kanpur 23, aligarh muslim university 21, university of mysore 20, international institute of information technology 19, university of delhi 18, institute of mathematical sciences 17, bengal engineering and science university 17, indian institute of technology kharagpur 14, indian institute of technology bombay 14, bhabha atomic research centre 13, annamalai university 13, university of hyderabad 12, ibm india research lab. 12, birla institute of technology and science 12, psg college of technology 11, indian institute of technology guwahati 11, vidyasagar university 10).

(**Authors:** chaudhuri, subhasis 15, kumar, rajeev 13, guru, d.s. 12, ganesan, l. 12, deb, kalyanmoy 12, das, sandip 12, asokan, p. 12, tiwari, m.k. 11, pal, sankar k. 11, nagabhushan, p. 11).

(**Sources:** lect. notes comput. sci. 358, proc spie int soc opt eng 55, int j adv manuf technol 51, appl math comput (new york) 29, proc. int. conf. intelligent sensing info. proces. 24, eur j oper res 24, pattern recogn. lett. 23, j. appl. math. comp. 21, inf. technol. j. 19, proc. indicon 2005 int. conf. ieee india council 16, proc ieee int conf vlsi des 16, pattern recogn. 16, discrete math 15, comput math appl 14, astron. astrophys. 14, sadhana 13, 2006 ieee power india conf. 13, int. j. remote sens. 12, electr. power comp. syst. 12, proc indian acad sci math sci 11, linear algebra its appl 11, proc. world enformatika. conf. 10, lect notes artif intell 10, int j inf manage sci 10, int j comput math 10).

APPENDIX E

INSPEC DATABASE TAXONOMIES
(2005-2006)

Taxonomy Diagram and Node Details

INSPEC Taxonomy (2005-2006)

INSPEC (2005-2006) Hierarchical Taxonomy (Levels 0 - 4)				
Level 0	**Level 1**	**Level 2**	**Level 3**	**Level 4**
				Cluster {233} - 1,789 records information technology scientific and industrial research inventory and supply chain management / genetic algorithms food processing technology / soil research
				Cluster {240} - 1,852 records scientific and industrial research information technology signal and image processing pattern recognition and machine intelligence
				Cluster {213} - 850 records telecommunications wireless and photonic sensor networks
				Cluster {30} - 236 records scientific and industrial research information technology signal and image processing pattern recognition and machine intelligence
			Cluster {248} - 3,641 records advanced manufacturing technology computers and computation scientific and industrial research information technology	Cluster {189} - 431 records electric power systems and components electric power distribution and control linear and non-linear control systems
		Cluster {249} - 4,727 records advanced manufacturing technology computers and computation communications	Cluster {234} - 1,086 records advanced manufacturing technology communications telecommunications microwave and optical technology	Cluster {200} - 546 records electric power systems and components electric power distribution and control fuzzy and intelligent control / computer simulation
Cluster {254} - 18,851 records APPLIED PHYSICAL SCIENCES ELECTRICAL ENGINEERING COMPUTERS AND DATA PROCESSING ELECTRONICS PRODUCTION AND MANUFACTURING	Cluster {250} - 6,599 records COMPUTERS AND DATA PROCESSING PRODUCTION AND MANUFACTURING ELECTRICAL ENGINEERING ELECTRONICS	Cluster {243} - 1,872 records advanced manufacturing technology communications	Cluster {227} - 977 records advanced manufacturing technology scientific and industrial research electric power systems and components	Cluster {221} - 707 records solid-state / semi-conductor materials and devices microelectronics / VLSI Circuit Design
	Cluster {253} - 12,252 records APPLIED PHYSICAL SCIENCES	Cluster {247} - 4,904 records physical chemistry	Cluster {237} - 895 records advanced manufacturing technology materials engineering microwave and optical technology solid-state / semi-conductor materials and devices	Cluster {11} - 188 records microwave and optical technology microwave/microstrip antenna design radio space physics / electromagnetic wave propagation
		Cluster {252} - 7,348 records physical chemistry materials engineering	Cluster {239} - 1,656 records physics physical chemistry structural design and analysis chemical engineering physics of fluids	Cluster {211} - 838 records chemical engineering physics of fluids computational fluid dynamics plasma physics / magnetohydrodynamics / heat mass transfer
			Cluster {244} - 3,248 records physics materials engineering nuclear and particle physics astronomy and astrophysics solid-state/semi-conductor materials and devices	Cluster {216} - 818 records structural design and analysis composites and plastics finite element analysis
			Cluster {246} - 3,089 records physical chemistry materials engineering organic compounds crystal growth	Cluster {229} - 1,731 records nuclear and particle physics astronomy and astrophysics plasma physics / radio space physics / cosmology
			Cluster {251} - 4,259 records materials engineering organic compounds crystal growth thin solid films	Cluster {242} - 1,517 records astronomy and astrophysics plasma physics / radio space physics / cosmology earthquake and seismology research
				Cluster {241} - 1,526 records organic compounds crystal growth polycrystalline and nanostructured materials molecular organic crystals
				Cluster {236} - 1,563 records solid-state/semi-conductor materials and devices ferromagnetic materials superconductor science and technology
				Cluster {199} - 1,091 records thin solid films solid-state/semi-conductor materials and devices materials characterization solar energy / solar cell research
				Cluster {245} - 3,168 records organic compounds polymer science and technology / composites and plastics microstructure and material properties

INSPEC Level 1:

Level 1 is divided into two clusters with the following primary and secondary category headings:

Cluster {250}

Primary: COMPUTERS AND DATA PROCESSING, PRODUCTION AND MANUFACTURING, ELECTRICAL ENGINEERING and ELECTRONICS.

Secondary: Computers and Data Processing is focused on computation. Production and Manufacturing is focused on advanced manufacturing technology. Electronics is focused on communications.

INSPEC Level 1: Cluster 250 (6,599 Records)

(**Themes:** algorithm 3.4%, network 3.2%, system 3.1%, control 2.2%, paper 2.0%, imag 1.8%, design 1.8%, power 1.6%, model 1.5%, data 1.0%, inform 1.0%, scheme 1.0%, time 0.9%, optim 0.9%, oper 0.8%, simul 0.8%, applic 0.8%, filter 0.8%, comput 0.8%, (30.16%)).

(**Keywords:** internet 199, genetic algorithms 180, india 169, neural nets 142, wavelet transforms 140,ad hoc networks 126, optimisation 120, feature extraction 116, mobile radio 110, quality of service 104,computational complexity 101, molecular biophysics 99, genetic algorithm 95, learning (artificial intelligence) 92, fuzzy set theory 91, computational complexity 86, image segmentation 83, image coding 77, finite element analysis 77, wireless sensor networks 75, wireless lan 74, microstrip antennas 72, artificial neural network 70, error statistics 69, medical image processing 68, integrated circuit design 68, fuzzy logic 68, information retrieval 66,data mining 66, graph theory 62).

Cluster {253}

Primary: APPLIED PHYSICAL SCIENCES

Secondary: Physical Chemistry and Materials Engineering.

INSPEC Level 1: Cluster 253 (12,252 Records)

(**Themes:** temperatur 2.5%, film 2.1%, phase 1.2%, ion 1.1%, structur 1.0%, composit 1.0%, model 1.0%, energi 1.0%, magnet 1.0%, deg 0.9%, electron 0.9%, properti 0.8%, state 0.8%, field 0.8%, crystal 0.8%, surfac 0.8%, sampl 0.7%, conduct 0.7%, paramet 0.6%, (20.22%)).

(**Keywords:** x-ray diffraction 1231, organic compounds 980, x-ray diffraction 971, infrared spectra 905, scanning electron microscopy 773, fourier transform spectra 525, xrd 513, nanoparticles 473, transmission electron microscopy 419, zinc compounds 416, nanostructured materials 406, permittivity 371, crystal structure 367, semiconductor thin films 365, sem 355, 293 to 298 k 350, ii-vi semiconductors 347, electrical conductivity 347, particle size 339, electrical resistivity 330, room temperature 314, ultraviolet spectra 308, photoluminescence 286, raman spectra 279, energy gap 276,annealing 270, ferromagnetic materials 255, polymers 251, crystal microstructure 250, lead compounds 247).

INSPEC Level 4:

Level 4 is divided into sixteen (16) clusters. They are described in order of their listing in Table XY, starting from the top with the following tertiary category headings and single technology focus areas:

Cluster {233}

Tertiary: Information technology covers inventory and supply chain management and with focus on genetic algorithms. Scientific and Industrial Research covers Food processing technology with focus on dairy products and vegetable oils, and soil contamination/pollution experiments.

INSPEC Level 4: Cluster 233 (1,789 Records)

(**Themes:** system 4.1%, design 3.5%, product 2.7%, softwar 2.6%, librari 2.4%, cost 2.3%, inform 2.2%, paper 2.1%, model 1.4%, manufactur 1.2%, optim 1.2%, machin 1.2%, oper 1.1%, tool 1.0%, custom 1.0%, resourc 0.9%, test 0.9%, project 0.9%, suppli 0.8%, (34.28%).

(**Keywords:** india 137, internet 66, genetic algorithms 54, organisational aspects 45, supply chain management 43, optimisation 43, information technology 39, production engineering computing 32,decision making 31, maintenance engineering 30, decision making 30, design engineering 29, machining 27, inventory management 27, supply chain management 26, genetic algorithm 26,cost reduction 26, reliability 25,digital libraries 25, government policies 24, formal specification 24, agriculture 24, socio-economic effects 23, pricing 23, finite element analysis 23, electronic commerce 23,academic libraries 23, internet 22, integrated circuit design 22, program testing 21).

INSPEC Level 4: Cluster 233 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 242, indian inst. of sci. 49 , dept. of mech. eng. 41, nat. inst. of technol. 27, anna univ. 25, indian stat. inst. 24, jadavpur univ. 23, indian inst. of technol. delhi 20, indian inst. of manage. 17, central leather res. inst. 15, dept. of math. 14, birla inst. of technol. & sci. 14, nat. inst. of oceanogr. 13, ibm india res. lab. 12, tata manage. training centre 11, deemed univ. 11, annamalai univ. 11, psg coll. of technol. 10, indian inst. of technol. roorkee 10, national inst. of technol. 9, madurai kamaraj univ. 9, infosys technol. ltd. 9, indira gandhi centre for atomic res. 9, indian inst. of technol. madras 9, kumaraguru coll. of technol. 8).

(**Authors:** kumar, a. 26, kumar, s. 18, shankar, r. 14, deshmukh, s.g. 14, bowonder, b. 13, jain, p.k. 12, gupta, a. 12, wadhwa, s. 11, kumar, p. 11, tiwari, m.k. 10).

(**Sources:** j. sci. ind. res. 54, int. j. adv. manuf. technol. 48, curr. sci. 41, srels j. inf. manag. 37, ieema j. 34, j. mater. process. technol. 24, iaslic bull. 23, def. sci. j. 21, iete tech. rev. 20, energy policy 18, int. j. serv. technol. manag. 17, desidoc bull. inf. technol. 17, inf. stud. 16, telecommunications 15, sadhana 15, nucl. eng. des. 15, opsearch 14, int. inf. libr. rev. 14, proc. inst. mech. eng. b, j. eng. manuf. 13, indian j. eng. mater. sci. 13, hydrocarbon process. 13, eur. j. oper. res. 13, electron. libr. 13, int. j. prod. res. 11, wseas trans. environ. dev. 10).

Cluster {240}

Tertiary: Scientific and Industrial Research and Information Technology covers signal and image processing with focus on pattern recognition and machine intelligence and data mining.

INSPEC Level 4: Cluster 240 (1,852 Records)

(**Themes:** imag 11.9%, algorithm 11.0%, code 1.9%, data 1.6%, featur 1.6%, set 1.5%, wavelet 1.2%, paper 1.1%, scheme 1.1%, comput 1.1%, recognit 1.0%, cluster 0.9%, inform 0.9%, classif 0.9%, system 0.8%, object 0.8%, signal 0.8%, search 0.8%, databas 0.8%, (42.55%)).

(**Keywords:** wavelet transforms 115, feature extraction 108, molecular biophysics 86, computational complexity 84, image segmentation 80, image coding 76, genetic algorithms 63, medical image processing 62, computational complexity 62, data mining 59, image classification 58, internet 51, feature extraction 50 , pattern clustering 49, error statistics 48, image colour analysis 45, image reconstruction 43, fuzzy set theory 43, data compression 43, data mining 42, pattern classification 41, learning (artificial intelligence) 41, proteins 39, information retrieval 39, proteins 38, natural languages 36, matrix algebra 35, image resolution 35, image processing 35, graph theory 35).

INSPEC Level 4: Cluster 240 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 349, indian inst. of sci. 148, indian stat. inst. 87, int. inst. of inf. technol. 40, anna univ. 34, indian inst. of technol. madras 32, dept. of comput. sci. & eng. 25, jadavpur univ. 22, tata inst. of fundamental res. 19, mysore univ. 17, indian inst. of technol. delhi 17, nat. inst. of technol. 14, dept. of math. 14, dept. of electr. eng. 14, psg coll. of technol. 13, bengal eng. & sci. univ. 13, indian inst. of manage. 12, hyderabad univ. 12, inst. of math. sci. 11, ibm india res. lab. 11, aligarh muslim univ. 11, sant longowal inst. of eng. & technol. 10, indian inst. of inf. technol. 10, dhirubhai ambani inst. of inf. & commun. technol. 10, dept. of mech. eng. 10).

(**Authors:** kumar, a. 25, das, s. 23, kumar, r. 21, jawahar, c.v. 21, singh, k. 19, nagabhushan, p. 17, guru, d.s. 17, yegnanarayana, b. 15, pal, s.k. 15, chaudhuri, s. 15).

(**Sources:** pattern recognit. lett. 23, iete j. res. 22, pattern recognit. 18, curr. sci. 17, int. j. adv. manuf. technol. 13, appl. math. comput. 13, inf. stud. 11, signal process. 10, proc. spie - int. soc. opt. eng. 10, ieee trans. inf. theory 10, inf. technol. j. 9, ieee trans. signal process. 9, acta crystallogr. d, biol. crystallogr. 9, srels j. inf. manag. 8, opt. commun. 8, j. comput. sci. 8, iee proc., vis. image signal process. 8, wseas trans. comput. 7, sadhana 7, opt. eng., bellingham 7, opsearch 7, j. stat. plan. inference 7, j. discret. math. sci. cryptography 7, iete tech. rev. 7, ieee trans. commun. 7).

Cluster {213}

Tertiary: Telecommunications covers wireless sensor networks and photonic sensor networks with focus on cryptography.

INSPEC Level 4: Cluster 213 (850 Records)

(**Themes:** network 22.0%, node 7.3%, protocol 5.2%, mobil 3.8%, wireless 2.7%, secur 2.5%, rout 2.2%, scheme 2.0%, packet 1.6%, commun 1.2%, algorithm 1.2%, traffic 0.9%, channel 0.8%, access 0.8%, hoc 0.8%, path 0.8%, sensor 0.7%, qo 0.7%, tcp 0.6%, (58.46%)).

(**Keywords:** ad hoc networks 124, mobile radio 96, quality of service 93, internet 79, wireless sensor networks 67, wireless lan 58, telecommunication traffic 53, protocols 48, mobile computing 46, telecommunication security 44, telecommunication congestion control 44, routing protocols 42, telecommunication network routing 41, routing protocols 40, wavelength division multiplexing 37, transport protocols 37, telecommunication security 36, telecommunication traffic 35, telecommunication network topology 33, cellular radio 33, cellular radio 33, access protocols 32, manet 31, 3g mobile communication 31, mobility management (mobile radio) 30, probability 29, optical fibre networks 28, telecommunication network routing 27, qos 27, ip networks 27).

INSPEC Level 4: Cluster 213 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 160, indian inst. of sci. 64, anna univ. 37, indian stat. inst. 21, dept. of comput. sci. & eng. 20, jadavpur univ. 17, inst. for dev. & res. in banking technol. 15, nat. inst. of technol. 14, dept. of electron. & commun. eng. 14, appl. res. group 13, honeywell technol. solutions lab. 11, int. inst. of inf. technol. 10, univ. of calcutta 8, indian inst. of technol. madras 8, jawaharlal nehru univ. 7, dept. of cse 7, wipro technol. 6, phys. res. lab. 6, birla inst. of technol. & sci. 6, tata inst. of fundamental res. 5, psg coll. of technol. 5, netaji subhas inst. of technol. 5, motilal nehru nat. inst. of technol. 5, kurukshetra univ. 5).

(**Authors:** murthy, c.s.r. 17, misra, m. 15, shanmugavel, s. 14, manoj, b.s. 13, kumar, a. 13, nandi, s. 11, joshi, r.c. 10, sridhar, v. 9, siva ram murthy, c. 9, saha, d. 9).

(**Sources:** telecommunications 30, iete j. res. 20, physica a 14, iete tech. rev. 12, j. comput. sci. 11, wseas trans. commun. 10, inf. technol. j. 8, wseas trans. comput. 6, phys. rev. e, stat. nonlinear soft matter phys. 6, ieee trans. power deliv. 4, srels j. inf. manag. 3, photonic netw. commun. 3, opt. commun. 3, j. syst. softw. 3, j. syst. archit. 3, j. parallel distrib. comput. 3, j. high speed netw. 3, int. j. commun. syst. 3, int. j. bus. data commun. netw. 3, ieee trans. mob. comput. 3, ieee trans. consum. electron. 3, comput. netw. 3, comput. commun. 3, ad hoc netw. 3, wseas trans. inf. sci. applic. 2, wirel. netw. 2).

Cluster {30}

Tertiary: Scientific and Industrial Research and Information Technology covers signal and image processing with focus on pattern recognition and machine intelligence, genetic algorithms and artificial intelligence.

INSPEC Level 4: Cluster 30 (236 Records)

(**Themes:** neural 22.5%, network 18.2%, neural.network 12.6%, ann 4.5%, train 4.1%, artifici 2.7%, artificial.neural 2.7%, neural.networks 2.1%, artificial.neural.network 1.7%, model 1.5%, classif 0.7%, data 0.7%, back.propagation 0.6%, learn 0.6%, input 0.6%, algorithm 0.5%, network.ann 0.5%, neural.network.ann 0.5%, neuron 0.4%, back 0.4%)

(**Keywords:** neural nets 97, artificial neural network 52, backpropagation 46, feedforward neural nets 35, learning (artificial intelligence) 27, multilayer perceptrons 22, production engineering computing 18, power engineering computing 18, artificial neural networks 18, artificial neural network 15, pattern classification 14, genetic algorithms 14, neural network 12, fuzzy neural nets 12, backpropagation 12, time series 11, neural nets 11, genetic algorithm 10, self-organising feature maps 8, regression analysis 8, radial basis function networks 8, multilayer perceptron 8, ann 8, wear 7, recurrent neural nets 7, power system analysis computing 7, pattern recognition 7, neural networks 7, multilayer perceptrons 7, finite element analysis 7).

INSPEC Level 4: Cluster 30 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 45, anna univ. 8, jadavpur univ. 7, psg coll. of technol. 6, indian inst. of sci. 6, nat. inst. of technol. 5, annamalai univ. 5, indian inst. of technol. madras 4, dept. of electr. eng. 4, dept. of electr. & instrum. eng. 4, deemed univ. 4, nat. inst. of sci. & technol. 3, indian stat. inst. 3, dept. of mech. eng. 3, dept. of comput. sci.

& eng. 3, vishwakarma inst. of technol. 2, sastra 2, regional res. lab. 2, nitttr 2, nerist 2, national inst. of technol. 2, mumbai univ. 2, metallurgy & mater. group 2, mater. dev. group 2, jntu coll. of eng. 2).

(**Authors:** karthikeyan, b. 6, kalra, p.k. 6, gopal, s. 6, chakraborty, d. 6, raj, b. 5, pattnaik, s.s. 5, panda, g. 5, panda, d.c. 5, pal, s.k. 5, mishra, d. 5).

(**Sources:** int. j. adv. manuf. technol. 9, j. sci. ind. res. 6, neural comput. appl. 5, j. mater. process. technol. 5, expert syst. appl. 5, neural netw. world (czech republic) 4, def. sci. j. 4, trans. indian inst. met. 3, neurocomputing 3, mater. sci. eng. a, struct. mater., prop. microstruct. process. 3, mater. manuf. process. 3, indian j. eng. mater. sci. 3, ieema j. 3, comput. chem. eng. 3, appl. soft comput. 3, struct. eng. mech. (south korea) 2, soft comput. 2, sens. actuators b, chem. 2, proc. spie - int. soc. opt. eng. 2, j. sound vib. 2, j. process control 2, j. indian inst. sci. 2, j. appl. polym. sci. 2, int. j. knowl.-based intell. eng. syst. 2, indian j. radio space phys. 2).

Cluster {189}

Tertiary: Electric Power Systems and Components covers electric power distribution and control with focus on linear and non-linear control systems and smart materials.

INSPEC Level 4: Cluster 189 (431 Records)

(**Themes:** control 42.3%, fuzzi 8.9%, system 5.7%, logic 1.2%, output 1.0%, power 1.0%, model 1.0%, fuzzy.logic 0.8%, input 0.8%, design 0.7%, time 0.6%, simul 0.6%, feedback 0.6%, paper 0.5%, motor 0.5%, dynam 0.5%, oper 0.4%, stabil 0.4%, scheme 0.4%, (68.45%)).

(**Keywords:** fuzzy control 50, control system synthesis 45, nonlinear control systems 42, fuzzy logic 38, feedback 31, neurocontrollers 29, machine control 26, variable structure systems 25, fuzzy set theory 25, adaptive control 25, control system synthesis 23, genetic algorithms 22, pi control 20, stability 18, power system control 18, fuzzy control 17, intelligent control 15, electric current control 15, voltage control 14, stability 14, genetic algorithm 14, fuzzy systems 14, discrete time systems 14, angular velocity control 14, robust control 13, three-term control 12, power system stability 12, multivariable control systems 12, mobile robots 11, linearisation techniques 11).

INSPEC Level 4: Cluster 189 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 109, indian inst. of sci. 29, dept. of electr. eng. 16, nat. inst. of technol. 14, anna univ. 12, jadavpur univ. 11, psg coll. of technol. 7, dept. of electr. & electron. eng. 5, beant coll. of eng. & technol. 5, raman res. inst. 4, jawaharlal nehru technol. univ. 4, indian inst. of technol. guwahati 4, indian inst. of technol. bombay 4, dept. of math. 4, dept. of instrum. & control eng. 4, dept. of chem. eng. 4, vellore inst. of technol. 3, nsit 3, maulana azad nat. inst. of technol. 3, iit 3, electr. eng. dept. 3, dept. of instrum. 3, central mech. eng. res. inst. 3, burdwan univ. 3, birla inst. of technol. & sci. 3).

(**Authors:** bandyopadhyay, b. 22, janardhanan, s. 10, chidambaram, m. 9, singh, s.p. 7, kumar, a. 6, kulkarni, a.m. 6, kar, i.n. 6, singh, b. 5, samanta, a.n. 5, kumar, r. 5).

(**Sources:** j. sci. ind. res. 15**,** isa trans. 9, ieema j. 7, ieee trans. power syst. 7, adv. model. anal. c, syst. anal. control des. simul. cad 7, fuzzy sets syst. 6, smart mater. struct. 5, iete tech. rev. 5, ieee trans. power electron. 5, ieee trans. autom. control 5, electr. power syst. res. 5, def. sci. j. 5, comput. chem. eng. 5, phys. lett. a 4, math. comput. model. 4, j. guid. control dyn. 4, int. j. model. simul. 4, int. j. control 4, indian j. eng. mater. sci. 4, wseas trans. syst. 3, wseas trans. power syst. 3, soft comput. 3, model. meas. control a, gen. phys. electron. electr. eng. 3, j. inst. eng. (india) electr. eng. div. 3, j. disp. technol. 3).

Cluster {200}

Tertiary: Electric Power Systems and Components covers electric power distribution and control with focus on fuzzy and intelligent control and computer simulation.

INSPEC Level 4: Cluster 200 (546 Records)

(**Themes:** voltag 13.4%, power 13.3%, motor 3.6%, convert 3.4%, load 2.8%, control 2.4%, switch 2.3%, current 2.2%, system 1.6%, invert 1.6%, induct 1.5%, harmon 1.4%, oper 1.1%, simul 0.9%, bu 0.9%, regul 0.7%, reactive.power 0.7%, power.factor 0.7%, compens 0.7%, (55.88%)).

(**Keywords:** power supply quality 47, voltage control 40, invertors 40, induction motor drives 38, power factor 35, switching convertors 31, ac-dc power convertors 31, power capacitors 28, finite element analysis 27, rotors 26, static var compensators 25, reactive power 25, harmonics suppression 25, pwm invertors 24, asynchronous generators 24, machine vector control 23, machine control 23, harmonic distortion 23, electric current control 23, torque 22, power factor correction 22, mathematics computing 21, load flow 21, induction motors 20, active filters 20, pwm power convertors 19, power engineering computing 19, voltage regulation 18, power harmonic filters 18, permanent magnet motors 16).

INSPEC Level 4: Cluster 200 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 143, indian inst. of sci. 35, dept. of electr. eng. 26, nat. inst. of technol. 20, dept. of electr. & electron. eng. 16, anna univ. 15, indian inst. of technol. delhi 14, inst. for plasma res. 7, visvesvaraya nat. inst. of technol. 6, indian inst. of technol. madras 6, birla inst. of technol. & sci. 5, annamalai univ. 5, reactor control div. 4, psg coll. of technol. 4, jadavpur univ. 4, electr. eng. dept. 4, dept. of electr. engg. 4, centre for adv. technol. 4, aligarh muslim univ. 4, texas instruments 3, pondicherry eng. coll. 3, nirma univ. of sci. & technol. 3, national inst. of technol. 3, int. inst. of inf. technol. 3, iit 3).

(**Authors:** singh, b. 41, rajagopal, k.r. 20, bhuvaneswari, g. 20, gopakumar, k. 15, ghosh, a. 15, garg, v. 14, kanchan, r.s. 13, tekwani, p.n. 12, singh, b.p. 10, kumar, a. 10).

(**Sources:**, ieema j. 21, ieee trans. power deliv. 18, iee proc., electr. power appl. 15, electr. power syst. res. 14, int. j. energy technol. policy 10, iee proc., gener. transm. distrib. 10, int. j. electr. power energy syst. 8, ieee trans. magn. 8, model. meas. control a, gen. phys. electron. electr. eng. 7, ieee trans. ind. electron. 7, barc newsl. 7, j. textile inst. 6, ieee trans. power electron. 6, ieee trans. energy convers. 6, amer. j. appl. sci. 6, j. appl. phys. 5, j. sci. ind. res. 4, j. inst. eng. (india) electr. eng. div. 4, int. j. power energy syst. 4, epe j. 4, bhel j. 4, aip conf. proc. 4, sol. energy mater. sol. cells 3, proc. inst. mech. eng. d, j. automob. eng. 3, mech. syst. signal process. 3).

Cluster {221}

Tertiary: Solid-State / Semi-Conductor Materials and Devices covers microelectronics with focus on VLSI Circuit Design.

INSPEC Level 4: Cluster 221 (707 Records)

(**Themes:** filter 13.3%, circuit 11.6%, gate 3.3%, devic 2.2%, design 2.2%, current 2.1%, nois 1.9%, fault 1.8%, signal 1.8%, voltag 1.8%, simul 1.7%, frequenc 1.1%, power 1.0%, channel 1.0%, amplifi 0.9%, model 0.9%, mosfet 0.8%, digit 0.8%, mode 0.8%, (51.76%)).

(**Keywords:** mosfet 53, semiconductor device models 45, integrated circuit design 36, semiconductor device models 31, band-pass filters 31, vlsi 26, low-pass filters 25, current-mode circuits 22, logic design 21, integrated circuit testing 21, cmos integrated circuits 21, current conveyors 19, mosfet 19, analogue-digital conversion 19, spice 18, low-power electronics 16, fir filters 16, cmos integrated circuits 16, si 15, operational amplifiers 15, notch filters 15, logic gates 15, field programmable gate arrays 15, low-power electronics 14, iii-v semiconductors 14, high-pass filters 14, fault diagnosis 14, silicon-on-insulator 13, fault simulation 13, circuit simulation 13).

INSPEC Level 4: Cluster 221 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 162**,** indian inst. of sci. 32, indian inst. of technol. madras 20, banaras hindu univ. 20, jadavpur univ. 18, nat. inst. of technol. 14, dept. of electr. eng. 14, kashmir univ. 13, saha inst. of nucl. phys. 11, anna univ. 11, int. inst. of inf. technol. 10, cochin univ. of sci. & technol. 10, univ. of delhi 8, dept. of phys. 8, indian inst. of technol. delhi 7, dept. of electron. eng. 7, delhi univ. 7, central res. lab. 7, bengal eng. & sci. univ. 7, jammu univ. 5, indian inst. of technol. mumbai 5, dept. of electron. 5, bhabha atomic res. centre 5, aligarh muslim univ. 5, vidyasagar univ. 4).

(**Authors:** kumar, m.j. 19, gupta, r.s. 19, gupta, m. 16, sarkar, s. 14, shah, n.a. 13, senani, r. 10, patra, a. 10, srinivas, m.b. 9, banerjee, s. 9, agarwal, r.p. 9).

(**Sources:** microw. opt. technol. lett. 21**,** ieee trans. electron devices 20, indian j. pure appl. phys. 14, solid-state electron. 13, microelectron. int. 11, int. j. electron. 10, iete j. res. 9, ieema j. 9, signal process. 8, semicond. sci. technol. 7, iee proc., circuits devices syst. 7, analog integr. circuits signal process. 7, phys. rev. lett. 6, opt. commun. 6, ieee trans. power deliv. 6, ieee trans. circuits syst. ii, analog digit. signal process. 6, ieee microw. wirel. compon. lett. 6, wseas trans. signal process. 5, wseas trans. circuits syst. 5, pramana j. phys. 5, phys. scr. 5, opt. eng., bellingham 5, indian j. eng. mater. sci. 5, ieee trans. educ. 5, rev. sci. instrum. 4).

Cluster {11}

Tertiary: Microwave and Optical Technology covers microwave/microstrip antenna design with focus on radio space physics and electromagnetic wave propagation.

INSPEC Level 4: Cluster 11 (188 Records)

(**Themes:** antenna 41.3%, microstrip 8.4%, patch 6.7%, slot 2.6%, bandwidth 2.5%, microstrip.antenna 2.1%, frequenc 2.0%, radiat 1.8%, reson 1.5%, rectangular 1.1%, arrai 0.9%, ghz 0.9%, feed 0.9%, band 0.9%, dual 0.7%, compact 0.6%, rectangular.microstrip 0.6%, design 0.6%, fed 0.5%, beam 0.4%)

(**Keywords:** microstrip antennas 67, antenna feeds 49, antenna radiation patterns 42, broadband antennas 34, antenna radiation patterns 34, multifrequency antennas 25, electromagnetic wave polarisation 19, dielectric resonator antennas 19, microstrip antennas 18, slot antennas 16, uhf antennas 15, broadband antennas 15, microstrip antenna arrays 13, rectangular microstrip antenna 12, uhf antennas 11, microwave antennas 11, wireless lan 10, resonant frequency 10, radiation characteristics 10, multifrequency antennas 10, radiation pattern 9, monopole antennas 9, microstrip lines 9, impedance bandwidth 9, slot antennas 8, input impedance 8, electric impedance 8, antenna theory 8, microstrip transmission line 7, finite element analysis 7).

INSPEC Level 4: Cluster 11 Bibliometrics

(**Author Affiliations:** cochin univ. of sci. & technol. 38, dept. of electr. eng. 19, indian inst. of technol. 17, banaras hindu univ. 14, sameer 8, univ. of calcutta 6, central res. lab. 5, birla inst. of technol. 5, sameer-centre for electromagn. 4, rajasthan univ. 4, madhav inst. of technol. & sci. 3, dhirubhai ambani inst. of inf. & commun. technol. 3, dept. of mech. eng. 3, tata inst. of fundamental res. 2, res. center imarat 2, malaviya nat. inst. of technol. 2, gulbarga univ. 2, fr c rodrigues inst. of technol. 2, div. of ceramic technol. 2, dept. of ece 2, centre for electromagn. 2, visva-bharati univ. 1, variable energy cyclotron centre 1, univ. of rajasthan 1, univ. of delhi 1).

(**Authors:** mohanan, p. 31, kumar, g. 18, vasudevan, k. 17, deshmukh, a.a. 16, aanandan, c.k. 16, vishvakarma, b.r. 13, mathew, k.t. 11, suma, m.n. 10, yohannan, j. 9, shynu, s.v. 9).

(**Sources:** microw. opt. technol. lett. 48, indian j. radio space phys. 16, electron. lett. 10, ieee trans. antennas propag. 6, ieee antennas wirel. propag. lett. 6, j. electromagn. waves appl. 3, pramana j. phys. 2, iete tech. rev. 2, iete j. res. 2, ieee microw. wirel. compon. lett. 2, curr. sci. 2, thin-walled struct. 1, smart mater. struct. 1, proc. natl. acad. sci. india a, phys. sci. 1, phys. lett. b 1, nonlinear anal. theory methods appl. 1, microw. j. euro-global ed. 1, microelectron. int. 1, j. sci. ind. res. 1, int. j. rf microw. comput. aided eng. 1, ieee trans. veh. technol. 1, ieee trans. magn. 1, ieee trans. electromagn. compat. 1, iee proc., microw. antennas propag. 1, iee proc., commun. 1).

Cluster {211}

Tertiary: Chemical Engineering and Physics of Fluids covers computational fluid dynamics, plasma physics, magnetohydrodynamics and heat mass transfer.

INSPEC Level 4: Cluster 211 (838 Records)

(**Themes:** flow 16.2%, fluid 5.3%, heat 5.2%, veloc 2.9%, heat.transfer 2.0%, pressur 1.9%, model 1.6%, transfer 1.6%, number 1.6%, wall 1.4%, convect 1.2%, equat 1.1%, turbul 0.9%, reynold 0.8%, cylind 0.8%, liquid 0.8%, numer 0.7%, air 0.7%, porou 0.7%, (48.07%)).

(**Keywords:** heat transfer 123, flow instability 95, laminar flow 78, flow simulation 73, computational fluid dynamics 58, flow through porous media 57, boundary layers 54, two-phase flow 52, natural convection 52, vortices 50, viscosity 50, external flows 50, magnetohydrodynamics 47, pipe flow 46, friction 44, reynolds number 42, navier-stokes equations 42, convection 42, convection 42, turbulence 41, mass transfer 41, jets 38, channel flow 37, confined flow 35, drag 34, turbulence 32, hydrodynamics 30, fluid oscillations 29, numerical analysis 28, prandtl number 27).

INSPEC Level 4: Cluster 211 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 190, indian inst. of sci. 55, indian inst. of technol. madras 40, nat. inst. of technol. 20, gulbarga univ. 16, dept. of mech. eng. 14, univ. of mumbai 13, rajasthan univ. 13, indian stat. inst. 13, dept. of math. 13, jadavpur univ. 12, indian inst. of technol. guwahati 12, indian inst. of technol. delhi 11, inst. for plasma res. 9, deemed univ. 9, anna univ. 9, indian inst. of technol. kanpur 8, eng. mech. unit 8, indian inst. of technol. roorkee 7, dept. of phys. 7, dept. of aerosp. eng. 7, bhabha atomic res. centre 6, tata res. dev. & design centre 5, mumbai univ. 5, indian inst. of technol. mumbai 5).

(**Authors:** joshi, j.b. 13, sunil 12, das, p.k. 11

chakraborty, s. 11, bhattacharyya, s. 11, mittal, s. 10, kumar, a. 10, tiwari, g.n. 9, sharma, a. 9, das, s.k. 9)

(**Sources:** int. j. heat mass transf. 55**,** chem. eng. sci. 34, j. fluid mech. 20, ultra sci. phys. sci. 16, phys. fluids 15, heat mass transf. 14, int. j. numer. methods fluids 12, int. j. appl. mech. eng. 12, chem. eng. j. 12, renew. energy 11, phys. plasmas 11, chem. eng. res. des. 11, trans. asme, j. heat transf. 10, pramana j. phys. 10, model. meas. control b, solid & fluid mech. & thermics, robot., mech. syst., civil eng. 10, int. j. thermal sci. 10, int. commun. heat mass transf. 10, indian j. eng. mater. sci. 10, phys. rev. lett. 9, appl. math. comput. 9, numer. heat transf. a, appl. 8, j. sci. ind. res. 8, j. propuls. power 8, z. angew. math. phys. 7, proc. natl. acad. sci. india a, phys. sci. 7).

Cluster {216}

Tertiary: Structural Design and Analysis with focus on composites and plastics and finite element analysis.

INSPEC Level 4: Cluster 216 (818 Records)

(**Themes:** equat 9.5%, wave 4.2%, nonlinear 4.1%, element 3.3%, plate 3.1%, numer 2.8%, solut 2.6%, finit 1.8%, linear 1.4%, order 1.3%, finite.element 1.3%, boundari 1.1%, deriv 1.1%, propag 1.0%, theori 1.0%, model 1.0%, approxim 0.9%, function 0.8%, shell 0.7%, (43.91%)).

(**Keywords:** finite element analysis 122, vibrations 88 plates (structures) 88, laminates 51, nonlinear differential equations 43, beams (structures) 43, shells (structures) 35, shear deformation 35, boundary-value problems 34, finite element analysis 31, elasticity 30, finite element method 28, differential equations 28, eigenvalues and eigenfunctions 27, thermoelasticity 26, thermoelasticity 26, buckling 26, variational techniques 24, partial differential equations 23, nonlinear equations 23, functionally graded materials 23, wave propagation 22, numerical analysis 22, piezoelectric materials 21, nonlinear dynamical systems 20, damping 20, fourier transforms 19, convergence of numerical methods 19, approximation theory 19, iterative methods 18).

INSPEC Level 4: Cluster 216 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 138, indian inst. of sci. 81, indian inst. of technol. madras 23, kurukshetra univ. 22, dept. of math. 22, indian stat. inst. 17, dept. of phys. 17, jadavpur univ. 15, nat. inst. of technol. 14, indian inst. of technol. mumbai 14, bharathidasan univ. 13, univ. of delhi 12, indian inst. of technol. delhi 12, birla inst. of technol. 11, banaras hindu univ. 11, delhi univ. 10, anna univ. 8, punjabi univ. 7, panjab univ. 7, univ. of pune 6, pondicherry univ. 6, inst. of armament technol. 6, dept. of mech. eng. 6, burdwan univ. 6, birla inst. of technol. & sci. 6).

(**Authors:** kumar, r. 24**,** gopalakrishnan, s. 17, kapuria, s. 15, mohanty, r.k. 11, kumar, a. 11, singh, s. 10, sharma, a. 10, porsezian, k. 10, nath, y. 10, lakshmanan, m. 10).

(**Sources:**, appl. math. comput. 54, j. sound vib. 49, compos. struct. 20, phys. plasmas 17, int. j. solids struct. 17, pramana j. phys. 16, j. phys. a, math. gen. 15, thin-walled struct. 13, sadhana 13, int. j. appl. mech. eng. 13, j. reinf. plast. compos. 12, j. therm. stresses 11, phys. lett. a 10, chaos solitons fractals 9, smart mater. struct. 8, phys. rev. e, stat. nonlinear soft matter phys. 8, int. j. crashworthiness 8, trans. asme. j. vib. acoust. 7, struct. eng. mech. (south korea) 7, aiaa j. 7, phys. scr. 6, j. vib. control 6, iete j. res. 6, finite elem. anal. des. 6, comput. math. appl. 6).

Cluster {229}

Tertiary: Nuclear and Particle Physics and Astronomy and Astrophysics with focus on plasma physics, radio space physics and cosmology.

INSPEC Level 4: Cluster 229 (1,731 Records)

(**Themes:** energi 4.1%, model 3.9%, state 3.5%, quantum 1.9%, calcul 1.4%, theori 1.3%, function 1.2%, mass 1.2%, potenti 1.1%, section 1.0%, electron 1.0%, cross 1.0%, field 1.0%, interact 0.9%, excit 0.8%, coupl 0.7%, two 0.7%, densiti 0.7%, system 0.7%, (28.94%)).

(**Keywords:** cosmology 86, ground states 62, cosmology 52, excited states 49, ab initio calculations 49, black holes 48, monte carlo methods 39, gravitation 39, wave functions 36, supersymmetry 36, electronic density of states 36, heavy ion-nucleus reactions 36, space-time configurations 35, iii-v semiconductors 35, ground state 35, general relativity 33, energy gap 33, quantum theory 32, heavy ion-nucleus reactions 32, density functional theory 32, space-time configurations 31, chaos 31, quantum chromodynamics 30, string theory 29, string theory 29, entropy 28, organic compounds 27, nuclei with mass number 90 to 149 27, atom-photon collisions 27, nuclear energy level transitions 26).

INSPEC Level 4: Cluster 229 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 165, saha inst. of nucl. phys. 83, indian inst. of sci. 82, tata inst. of fundamental res. 75, dept. of phys. 72, jadavpur univ. 48, harish-chandra res. inst. 47, bhabha atomic res. centre 34, inst. of phys. 32, panjab univ. 31, inst. of math. sci. 31, dept. of math. 30, aligarh muslim univ. 28, univ. of delhi 26, phys. res. lab. 26, univ. of hyderabad 21, indian stat. inst. 21, variable energy cyclotron centre 19, indian inst. of astrophys. 18, delhi univ. 18, banaras hindu univ. 18, univ. of calcutta 15, s.n. bose nat. centre for basic sci. 15, raman res. inst. 15, inter-univ. centre for astron. & astrophys. 15).

(**Authors:** kumar, a. 25**,** kumar, s. 22, ghosh, s. 20, singh, n. 19, kumar, r. 19, chatterjee, a. 17, singh, r.p. 15, sen, a. 15, sidharth, b.g. 14, rahaman, f. 13).

(**Sources:** phys. rev. d 98, pramana j. phys. 90, phys. rev. c, nucl. phys. 72, phys. lett. b 54, phys. rev. e, stat. nonlinear soft matter phys. 46, phys. rev., b, condens, matter mater. phys. 45, phys. rev. a, at. mol. opt. phys. 45, jhep, j. high energy phys. 38, j. chem. phys. 38, astrophys. space sci. 37, phys. lett. a 34, phys. rev. lett. 33, j. phys. b, at. mol. opt. phys. 33, j. phys. g, nucl. part. phys. 30, j. phys., condens. matter. 27, indian j. pure appl. phys. 27, j. phys. a, math. gen. 26, radiat. phys. chem. 24, physica b 21, class. quantum gravity 21, nucl. instrum. methods phys. res. b, beam interact. mater. at. 18, eur. phys. j. a 18, chem. phys. lett. 16, physica a 15, j. phys., conf. ser. 15).

Cluster {242}

Tertiary: Astronomy and Astrophysics with focus on plasma physics, radio space physics, cosmology, and earthquake and seismology research.

INSPEC Level 4: Cluster 242 (1,517 Records)

(**Themes:** ion 6.9%, laser 3.4%, irradi 3.2%, beam 2.0%, plasma 1.7%, solar 1.6%, puls 1.4%, region 1.3%, wave 1.3%, period 1.2%, fluenc 1.2%, wind 1.0%, earthquak 1.0%, emiss 1.0%, intens 0.9%, monsoon 0.9%, optic 0.9%, star 0.8%, electron 0.7%, (33.10%)).

(**Keywords:** india 151, ion beam effects 109, wind 60, oceanographic regions 50, earthquakes 45, rain 44, plasma density 42, aerosols 41, x-ray diffraction 38, photoluminescence 38, earthquakes 37, elemental semiconductors 36, nanostructured materials 35, silicon 34, stellar spectra 33, ion implantation 33, infrared spectra 32, plasma light propagation 29, gamma-ray effects 29, seismology 28, raman spectra 27, organic compounds 27, faulting 27, arabian sea 27, earth crust 27).

INSPEC Level 4: Cluster 242 Bibliometrics

(**Author Affiliations:**indian inst. of technol. 123, indian inst. of sci. 61, tata inst. of fundamental res. 57, indian inst. of astrophys. 55, nat. geophys. res. inst. 49, dept. of phys. 38, phys. res. lab. 33, centre for adv. technol. 30, indian inst. of tropical meteorol. 26, nat. inst. of oceanogr. 22, banaras hindu univ. 19, raman res. inst. 18, inst. of phys. 18, nucl. sci. centre 17, inst. for plasma res. 17, cochin univ. of sci. & technol. 16, indian inst. of technol. delhi 15, saha inst. of nucl. phys. 14, bhabha atomic res. centre 13, inter-univ. centre for astron. & astrophys. 12, guru nanak dev univ. 12, aligarh muslim univ. 12, univ. of delhi 11, tezpur univ. 11, space phys. lab. 11).

(**Authors:** avasthi, d.k. 44, kumar, r. 33, kumar, a. 27, singh, f. 22, kanjilal, d. 20, ghosh, s. 19, tripathi, v.k. 18, khan, s.a. 18, kumar, s. 17, singh, s. 13).

(**Sources:** curr. sci. 148**,** nucl. instrum. methods phys. res. b, beam interact. mater. at. 75, mon. not. r. astron. soc. 58, geophys. res. lett. 49, indian j. radio space phys. 45, astron. astrophys. 38, j. astrophys. astron. 36, phys. plasmas 33, pramana j. phys. 27, adv. space res. 23, astrophys. j. 21, phys. scr. 19, radiat. eff. defects solids 18, sol. phys. 17, j. appl. phys. 17, opt. commun. 16, j. phys. d, appl. phys. 16, radiat. meas. 15, opt. eng., bellingham 15, appl. phys. b, lasers opt. 15, j. atmos. sol.-terr. phys. 14, astrophys. j. lett. 14, appl. phys. lett. 14, radiat. phys. chem. 13, appl. opt. 13).

Cluster {241}

Tertiary: Organic Compounds and Crystal Growth covers polycrystalline and nanostructured materials, and molecular organic crystals with focus on molecular and biomolecular spectroscopy, and x-ray diffraction analysis.

INSPEC Level 4: Cluster 241 (1,526 Records)

(**Themes:** crystal 11.0%, bond 2.7%, glass 2.7%, middot 2.4%, molecul 2.2%, complex 2.1%, spectra 1.6%, fluoresc 1.5%, ion 1.4%, structur 1.4%, grown 1.2%, absorpt 1.2%, hydrogen 1.0%, solvent 1.0%, ar 1.0%, energi 1.0%, middot.middot 0.9%, optic 0.9%, state 0.8%, (38.77%)).

(**Keywords:** organic compounds 578, infrared spectra 348, x-ray diffraction 207, hydrogen bonds 178, density functional theory 174, crystal structure 174, fourier transform spectra 170, fluorescence 163, ab initio calculations 139, molecular configurations 122, ultraviolet spectra 121, molecular biophysics 112, raman spectra 105, optical materials 97, x-ray diffraction 93, visible spectra 90, zinc compounds 89, paramagnetic resonance 85, crystal growth from solution 82, ground states 81, visible spectra 80, excited states 78, photoluminescence 72, crystal structure 68, room temperature 65, lithium compounds 64, crystallisation 62, differential thermal analysis 60, nonlinear optics 59, vibrational states 57).

INSPEC Level 4: Cluster 241 Bibliometrics

(**Author Affiliations:** dept. of phys. 117, indian inst. of technol. 102, indian inst. of sci. 76, banaras hindu univ. 38, anna univ. 33, sri venkateswara univ. 31, dept. of chem. 28, univ. of delhi 27, jadavpur univ. 21, indian inst. of technol. madras 21, cochin univ. of sci. & technol. 21, bharathidasan univ. 20, univ. of pune 19, univ. of burdwan 18, indian inst. of chem. technol. 18, bhabha atomic res. centre 18, central leather res. inst. 17, annamalai univ. 16, alagappa univ. 16, pondicherry univ. 15, panjab univ. 15, dept. of solid state phys. 15, centre for adv. technol. 15, univ. of hyderabad 14, madurai kamaraj univ. 14).

(**Authors:** ramasamy, p. 25, bhattacharya, s. 25, kumar, a. 23, chandra, s. 23, krishnakumar, v. 21, rao, j.l. 18, mukherjee, t. 18, datta, a. 18, rai, s.b. 17, sen, p. 16).

(**Sources:** spectrochim. acta a, mol. biomol. spectrosc. 185**,** cryst. res. technol. 69, j. cryst. growth 68, chem. phys. lett. 67, theochem 59, j. chem. phys. 56, j. mol. struct. 53, indian j. pure appl. phys. 50, j. phys. chem. b 49, j. phys. chem. a 46, int. j. quantum chem. 29, phys. rev., b, condens, matter mater. phys. 24, j. chem. sci. 21, bull. mater. sci. 20, mater. lett. 19, physica b 18, j. raman spectrosc. 18, j. non-cryst. solids 18, j. phys. chem. solids 17, solid state commun. 16, pramana j. phys. 16, mater. chem. phys. 16, colloids surf. a, physicochem. eng. aspects 16, chem. phys. 15, j. lumin. 14).

Cluster {236}

Tertiary: Solid-State/Semi-Conductor Materials and Devices covers ferromagnetic materials with focus on x-ray diffraction analysis, electron/atomic force microscopy, and superconductor science and technology.

INSPEC Level 4: Cluster 236 (1,563 Records)

(**Themes:** magnet 10.6%, temperatur 9.4%, dielectr 3.8%, phase 3.5%, transit 2.7%, sampl 2.4%, field 2.2%, compound 1.9%, conduct 1.4%, dope 1.0%, frequenc 1.0%, resist 1.0%, spin 1.0%, ferromagnet 1.0%, substitut 0.9%, constant 0.9%, structur 0.8%, le 0.8%, depend 0.8%, (47.82%)).

(**Keywords:** x-ray diffraction 271, x-ray diffraction 207, permittivity 200, ferromagnetic materials 192, lanthanum compounds 164, electrical resistivity 160, magnetisation 159, dielectric constant 139, magnetic susceptibility 129, electrical conductivity 114, lead compounds 113, crystal structure 108, curie temperature 106, barium compounds 105, strontium compounds 96, ferroelectric ceramics 94, magnetization 93, room temperature 89, lattice constants 89, dielectric relaxation 87, 293 to 298 k 87, organic compounds 85, xrd 82, dielectric losses 81, metal-insulator transition 77, doping 77).

INSPEC Level 4: Cluster 236 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 162, indian inst. of sci. 98, dept. of phys. 71, tata inst. of fundamental res. 64, bhabha atomic res. centre 44, banaras hindu univ. 35, saha inst. of nucl. phys. 33, indian inst. of technol. madras 33, osmania univ. 30, nat. phys. lab. 18, dept. of solid state phys. 18, regional res. lab. 17, saurashtra univ. 16, centre for adv. technol. 16, raman res. inst. 15, rajasthan univ. 14, shivaji univ. 13, univ. campus 12, anna univ. 12, indira gandhi centre for atomic res. 11, dept. of mater. sci. 11, centre for liquid crystal res. 11, univ. of rajasthan 10, univ. of pune 10, synchrotron radiat. sect. 10).

(**Authors:** malik, s.k. 48**,** choudhary, r.n.p. 41, tyagi, a.k. 35, kumar, r. 32, kumar, a. 32, kumar, s. 29, nigam, a.k. 23, nirmala, r. 22, gupta, a. 17, singh, s. 16).

(**Sources:** phys. rev., b, condens, matter mater. phys. 128, j. appl. phys. 88, j. phys., condens. matter. 65, physica b 63, solid state commun. 54, j. magn. magn. mater. 54, ferroelectrics 51, indian j. pure appl. phys. 47, j. phys. chem. solids 35, appl. phys. lett. 34, pramana j. phys. 32, mater. sci. eng. b, solid-state mater. adv. technol. 30, mater. lett. 29, j. alloys compd. 28, j. mater. sci. 25, mater. chem. phys. 24, j. phys. d, appl. phys. 24, bull. mater. sci. 24, mater. res. bull. 16, supercond. sci. technol. 15, physica c 15, phys. rev. lett. 15, j. phys. chem. b 14, hyperfine interact. 13, phys. rev. e, stat. nonlinear soft matter phys. 12).

Cluster {199}

Tertiary: Thin Solid Films and Solid-State/Semi-Conductor Materials and Devices with focus on x-ray diffraction analysis, electron/atomic force microscopy, and solar energy / solar cell research.

INSPEC Level 4: Cluster 199 (1,091 Records)

(**Themes:** film 42.9%, deposit 6.2%, thin 4.1%, thin.films 2.6%, substrat 2.6%, optic 0.9%, temperatur 0.9%, anneal 0.9%, thick 0.8%, surfac 0.6%, layer 0.6%, dope 0.6%, structur 0.6%, oxid 0.5%, conduct 0.5%, films.deposited 0.5%, electr 0.5%, rai 0.4%, zno 0.4%, (67.52%)).

(**Keywords:** semiconductor thin films 327**,** x-ray diffraction 225, x-ray diffraction 213, scanning electron microscopy 171, ii-vi semiconductors 158, semiconductor growth 147, energy gap 137, thin films 133, nanostructured materials 132, annealing 128, zinc compounds 124, electrical resistivity 114, atomic force microscopy 108, infrared spectra 103, electrical conductivity 102, xrd 101, annealing 97, atomic force microscopy 96, si 93, optical properties 92, grain size 91, photoluminescence 88, surface morphology 86, polymer films 85, sem 84, 293 to 298 k 80, electrical properties 76, wide band gap semiconductors 75, indium compounds 75, x-ray photoelectron spectra 74).

INSPEC Level 4: Cluster 199 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 117, shivaji univ. 48, indian inst. of sci. 48, jadavpur univ. 29, cochin univ. of sci. & technol. 26, dept. of phys. 25, central electrochem. res. inst. 24, sri venkateswara univ. 22, indian inst. of technol. delhi 19, nat. phys. lab. 18, alagappa univ. 18, delhi univ. 17, anna univ. 17, dept. of mater. sci. 16, univ. of pune 15, inst. of phys. 15, saha inst. of nucl. phys. 14, dept. of instrum. 12, central glass & ceramic res. inst. 12, univ. of delhi 11, tech. phys. & prototype eng. div. 11, mahatma gandi univ. 11, indian inst. of technol. madras 11, electron. mater. div. 11, bharathiar univ. 11).

(**Authors:** avasthi, d.k. 20**,** vijayakumar, k.p. 18, menon, c.s. 18, kumar, a. 18, kumar, s. 17, dusane, r.o. 17, chattopadhyay, k.k. 17, lokhande, c.d. 16, agnihotry, s.a. 16).

(**Sources:** thin solid films 58, appl. surf. sci. 57, sol. energy mater. sol. cells 37, j. appl. phys. 37, mater. lett. 30, bull. mater. sci. 28, mater. chem. phys. 27, appl. phys. lett. 27, nucl. instrum. methods phys. res. b, beam interact. mater. at. 26, j. cryst. growth 25, sens. actuators b, chem. 24, mater. sci. eng. b, solid-state mater. adv. technol. 23, indian j. pure appl. phys. 21, j. phys. d, appl. phys. 20, surf. coat. technol. 19, semicond. sci. technol. 19, j. mater. sci. 19, ferroelectrics 19, physica b 17, j. mater. sci., mater. electron. 17, j. phys. chem. solids 16, pramana j. phys. 14, chem. phys. lett. 14, synth. met. 13, solid state commun. 13).

Cluster {245}

Tertiary: Organic Compounds with focus on polymer science and technology, composites and plastics, and microstructure and material properties.

INSPEC Level 4: Cluster 245 (3,168 Records)

(**Themes:** composit 3.7%, alloi 2.6%, coat 2.0%, deg 1.7%, temperatur 1.6%, particl 1.4%, polym 1.3%, powder 1.3%, oxid 1.2%, properti 1.1%, surfac 1.1%, size 1.1%, acid 1.1%, materi 1.1%, corros 1.0%, steel 1.0%, mechan 0.9%, phase 0.9%, strength 0.9%, (27.99%)).

(**Keywords:** scanning electron microscopy 531, x-ray diffraction 499, x-ray diffraction 417, infrared spectra 350, transmission electron microscopy 292, nanoparticles 289, xrd 263, fourier transform spectra 249, sem 234, particle size 216, organic compounds 210, polymer blends 205, tensile strength 183, crystal microstructure 180, aluminium alloys

171, polymers 169, hardness 153, heat treatment 151, nanostructured materials 150, mechanical properties 149, tem 147, nanocomposites 147, differential scanning calorimetry 147, microstructure 145, oxidation 144, sintering 141, polymerisation 140, silicon compounds 139, powders 139, nanotechnology 137).

INSPEC Level 4: Cluster 245 Bibliometrics

(**Author Affiliations:** indian inst. of technol. 450**,** indian inst. of sci. 134, dept. of chem. 70, indian inst. of technol. madras 66, nat. inst. of technol. 64, central electrochem. res. inst. 58, regional res. lab. 53, bhabha atomic res. centre 46, banaras hindu univ. 45, phys. & mater. chem. div. 41, jadavpur univ. 36, dept. of mater. sci. 36, defence metall. res. lab. 36, anna univ. 36, nat. metall. lab. 35, central glass & ceramic res. inst. 33, indian inst. of chem. technol. 32, centre for mater. for electron. technol. 32, mysore univ. 30, north maharashtra univ. 26, indian inst. of technol. roorkee 26, mater. sci. div. 25, dept. of mech. eng. 25, univ. of pune 24, dept. of phys. 21).

(**Authors:** ravi, v. 43, das, s. 37, kumar, s. 35, thomas, s. 32, prakash, s. 32, bhowmick, a.k. 31, chatterjee, s. 27, kumar, a. 26, pasricha, r. 25, chaudhuri, s. 24).

(**Sources:** j. appl. polym. sci. 167, mater. sci. eng. a, struct. mater., prop. microstruct. process. 120, trans. indian inst. met. 109, j. mater. sci. 95, bull. mater. sci. 82, mater. lett. 79, indian j. chem. technol. 71, j. sci. ind. res. 61, surf. coat. technol. 59, j. reinf. plast. compos. 46, mater. chem. phys. 45, j. power sources 45, j. membr. sci. 42, j. am. ceram. soc. 42, j. phys. chem. b 41, j. nanosci. nanotechnol. 39, mater. sci. eng. b, solid-state mater. adv. technol. 37, wear 36, j. mater. process. technol. 33, polym.-plast. technol. eng. 32, metall. mater. trans. a, phys. metall. mater. sci. 32, appl. surf. sci. 32, indian j. pure appl. phys. 31, polym. int. 30, indian j. eng. mater. sci. 30).